



2ND PARMA NANO-DAY WORKSHOP SCIENTIFICO

3-4 DICEMBRE 2015

AUDITORIUM PLESSO POLIFUNZIONALE
CAMPUS, AREA DELLE SCIENZE E DELLE TECNOLOGIE
UNIVERSITÀ DEGLI STUDI DI PARMA





Atti del workshop “Parma Nano-Day”

II edizione

Parma, 3-4 dicembre 2015

Convegno organizzato da

Nelson Marmioli, Direttore del Dipartimento di Bioscienze, Università degli Studi di Parma

Salvatore Iannotta, Direttore dell’Istituto dei Materiali per l’Elettronica ed il Magnetismo (IMEM),
CNR

con la collaborazione di

Elena Maestri, Dipartimento di Bioscienze, Università degli Studi di Parma

Roberta Ruotolo, Dipartimento di Bioscienze, Università degli Studi di Parma

Elisabetta Davolio Marani, Dipartimento di Bioscienze, Università degli Studi di Parma

con il patrocinio della Provincia di Parma



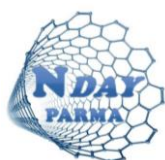
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DI PARMA**

e il contributo della



ISBN 978-88-941066-1-9

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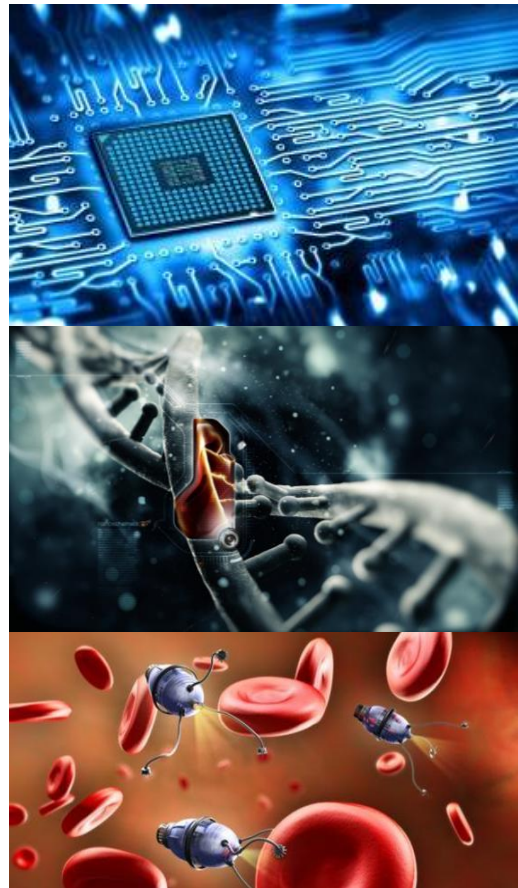
Premessa



Il convegno arrivato alla sua seconda edizione rappresenta un importante appuntamento per tutti coloro che lavorano nel campo delle nanotecnologie non solo in ambito universitario, ma anche aziendale. Lo scopo è quello di organizzare un evento in cui gli attori principali siano i **giovani ricercatori** e il loro lavoro, ma anche di permettere una costruttiva discussione sulla complessa situazione occupazionale e sulle prospettive dei giovani laureati. Il 2nd Parma Nano-Day, completamente gratuito per tutti i partecipanti, è stato organizzato in modo da prevedere **tre sessioni** con tematiche che spaziano dalla fisica, chimica e ingegneria, ad aspetti più vicini all'ambito biologico, farmaceutico, veterinario e medico, senza trascurare le implicazioni ambientali e la sicurezza alimentare. Particolare attenzione è stata rivolta alla innovazione scientifica e tecnologica in questo settore, promuovendo la multidisciplinarietà necessaria per condurre ricerche di alto livello. Nella prima giornata del convegno è stata organizzata una **tavola rotonda** aperta anche ad un pubblico più vasto con la partecipazione di personalità delle istituzioni, dell'accademia, dell'industria e della società civile. Prospettive e potenzialità dell'utilizzo dei nanomateriali in ambito industriale e aspetti critici come l'impatto ambientale e le implicazioni sulla salute umana sono solo alcuni degli argomenti trattati.

Il Comitato Scientifico

Il Comitato Scientifico che ha curato la preparazione del programma del convegno riunisce diversi esperti dell'Università degli Studi di Parma: Furio Brighenti (Dip. di Scienze degli Alimenti), Maria Careri (Dip. di Chimica), Attilio Corradi (Dip. di Scienze Medico-Veterinarie), Roberto De Renzi (Dip. di Fisica e Scienze della Terra), Antonio Mutti (Dip. di Medicina Clinica e Sperimentale), Patrizia Santi (Dip. di Farmacia), Stefano Selleri (Dip. di Ingegneria dell'Informazione) e Marco Vitale (Dip. di Scienze Biomediche, Biotecnologiche e Traslazionali). Fanno parte del comitato scientifico anche Andrea Chiesi della Chiesi Farmaceutici S.p.A., Erierto De Munari dell'ARPA, Elisa Molinari dell'Istituto di Nanoscienze (CNR) di Modena, Cecilia Monticelli del Dipartimento di Ingegneria dell'Università di Ferrara, Angela Montanari della Stazione Sperimentale per l'Industria delle Conserve Alimentari e Luca Vincetti del Dipartimento di Ingegneria "Enzo Ferrari" dell'Università di Modena e Reggio Emilia.



Il comitato scientifico



Nelson Marmioli

Dip. di Bioscienze
Università di Parma
Parco Area delle Scienze, 11/A
43124 PARMA
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**Principali titoli, tappe e realizzazioni della carriera scientifica**

1967-1971 Laurea in Scienze Biologiche presso l'Università degli Studi di Parma
1973-1977 Ricercatore Universitario, Università degli Studi di Parma
1978 Professore Associato presso l'Università di Chicago, IL, USA
1979-1982 Professore incaricato stabilizzato esterno, Università di Udine
1980-1986 Professore associato, Università di Parma
1986-1990 Professore ordinario, Università di Lecce
1990-1991 Cattedra di Genetica, Università di Bologna
1991-1995 Cattedra di Biologia, Università di Parma
Dal 1995 Cattedra di Tecnologie Ricombinanti, Università di Parma

Cariche attuali

Direttore del Dipartimento di Bioscienze, Membro del Senato Accademico Delegato del Rettore e Presidente del Comitato per lo Sport Universitario per l'Università di Parma; Coordinatore del Corso di Laurea in Biotecnologie e del Dottorato di Ricerca in Biotecnologie; Direttore del CINSA, Consorzio Interuniversitario Nazionale per le Scienze Ambientali.

Autore di oltre 250 pubblicazioni. Nel 2013 ha vinto il Premio Milton P. Gordon Award per l'eccellenza nel campo delle biotecnologie ambientali. Nel 2015 è editore per *Frontiers Plant Sciences* del *research topic* "Nanotoxicology and environmental risk assessment of engineered nanomaterials (ENMs) in plants".

Principali attività di ricerca

Basi genetiche e molecolari dell'interazione tra genotipo e ambiente in diversi organismi, dai microorganismi alle piante. Analisi proteomiche, genomiche, trascrittomiche. Applicazione di marcatori molecolari alla valutazione della variabilità genetica. Applicazione delle tecnologie del DNA ricombinante alle biotecnologie ambientali. Fitorimediazione, interazione tra piante superiori e agenti inquinanti (*indoor* e *outdoor*). Tracciabilità delle filiere alimentari per la sicurezza alimentare e la difesa dell'autenticità. *Food genomics*, proteomica e metabolomica per l'analisi degli alimenti. Coesistenza tra piante geneticamente modificate e non modificate. Metodologie innovative come contromisura nei confronti di attacchi deliberati contro risorse ambientali ed alimentari. Ruolo di miRNA umani nella risposta a processi infettivi e a processi patologici. Tossicogenomica basata su chip di cellule e di macromolecole biologiche. Nanotossicologia.



Salvatore Iannotta

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**Principali titoli, tappe e realizzazioni della carriera scientifica**

1976, Laurea in Fisica, Università di Bologna

1984, PhD in Chemistry at the (GWC)² [Guelph Waterloo Centre for Graduate Work in Chemistry, University of Waterloo, Ontario (Canada)]

Dal 1990 al 2002 è stato Direttore del Centro CeFSA per la Fisica della Aggregati del CNR.

E' stato membro del consiglio di amministrazione della Fondazione Bruno Kessler (FBK).

Professore a contratto presso l'Università di Trento (dal 1997) e docente presso la Scuola di Dottorato in Scienze e Tecnologia dei Materiali dell'Università degli Studi di Parma (dal 2009).

Cariche attuali

Direttore di IMEM, Istituto del CNR dedicato ai materiali per l'elettronica ed il magnetismo. Membro di *International Union for Vacuum Science Techniques and Applications (IUVSTA) - Nanostructures Division Committee* e della scuola di Dottorato di Scienza e Tecnologia dei Materiali dell'Università di Parma e di Scienze Fisiche della Materia dell'Università di Roma Tre (CNISM). Membro del comitato di diversi congressi nazionali ed internazionali e coordinatore di numerosi progetti di ricerca su base nazionale e internazionale. E' co-autore di oltre 100 pubblicazioni con più di 2000 citazioni ed è stato invitato come *speaker* in molte conferenze internazionali. Autore o co-autore di diverse monografie.

Principali attività di ricerca

Sintesi e caratterizzazione di materiali nanostrutturati e molecolari; materiali per fotonica, micro- e bio-elettronica organica, fasci supersonici di cluster metallici e di semiconduttori, nonché di aggregati molecolari; fisica atomica, ionica e molecolare; biosensori e sensori di gas attivi e passivi, rilevazione di gas traccia e relative applicazioni.

Furio Brighenti

Dip. di Scienze degli Alimenti, Università di Parma

Laurea in Scienze Alimentari presso l'Università degli Studi di Milano nel 1981. Specializzazione in Igiene presso la Facoltà di Medicina e Chirurgia dello stesso ateneo. Nel 1982 *Visiting Fellow* presso l'INRA di Nantes (FR). *Visiting Research Associate* presso il *Department of Nutritional Sciences* dell'*University of Toronto* dal 1987 al 1989. Nel 2001, Professore straordinario presso l'Istituto di Igiene dell'Ateneo di Parma. Confermato a Professore ordinario di Alimentazione e Nutrizione Umana, settore BIO/09 e quindi settore E5D (Fisiologia). Presidente dei corsi di Laurea e di Laurea Magistrale in Scienze Gastronomiche della Facoltà di Agraria dell'Università di Parma nel 2008-2012. Dal gennaio 2013 è Coordinatore del Dottorato di Ricerca in Scienze e Tecnologie Alimentari dell'Ateneo di Parma. Dal 2009 è Presidente della Società Italiana di Nutrizione Umana (SINU). E' membro del laboratorio di ricerca applicata sugli alimenti SITEIA-Parma. I suoi principali interessi di ricerca riguardano gli aspetti legati alla qualità nutrizionale degli alimenti e loro ruolo in un regime alimentare equilibrato, e in particolare la valutazione nutrizionale dei carboidrati complessi, fibra alimentare e sostanze antiossidanti negli alimenti e del loro effetto sul metabolismo e sulla funzionalità intestinale.

Maria Careri

Dip. di Chimica, Università di Parma

Professore Ordinario di Chimica Analitica presso l'Università di Parma.
Direttore del Dipartimento di Chimica dell'Università di Parma dal 25 Luglio 2012.
Presidente della Divisione di Chimica Analitica della Società Chimica Italiana nel triennio 2007-2009.
Direttore della Scuola Nazionale Metodologie Analitiche e Bioanalitiche in Spettrometria di Massa della Società Chimica Italiana.
Membro dell'*Editorial Board* delle riviste *Journal of Chromatography A* (Elsevier), *Current Analytical Chemistry* (Bentham Science Publisher) e *Analytical and Bioanalytical Chemistry* (Springer Verlag).

Andrea Chiesi

Chiesi Farmaceutici S.p.a.

Andrea è Direttore R&D Portfolio Management del Gruppo Chiesi. Il ruolo consiste nel coordinamento delle attività di pianificazione dei progetti di Ricerca e Sviluppo, nel concorso alla definizione del piano strategico e del budget annuale della R&D Chiesi, nel controllo dell'andamento delle attività e della spesa dell'unità di R&D e dei progetti. È inoltre co-fondatore ed Amministratore Delegato di Holostem Terapie Avanzate Srl, spin-off partecipato dall'Università di Modena e Reggio Emilia con in corso di registrazione il primo prodotto a base di cellule staminali corneali in Europa.



Attilio Corradi

Dip. di Scienze Medico-Veterinarie, Università di Parma

Nel 1981 laurea in Medicina Veterinaria. Nel 1985 ricercatore presso *'Hirnanatomisches Institut* (Berna, Svizzera). Nel 1987 e nel 1998 *Assistant Professor, Dept. of Pathology, Cornell University* (USA). Nel 2003 Presidente del CdS di Medicina Veterinaria. Da novembre 2006 Preside Facoltà di Medicina Veterinaria. Da luglio 2012 è Direttore del Dip. di Scienze Medico-Veterinarie e da aprile 2013 è Presidente della Conferenza dei Direttori di Dip. di Medicina Veterinaria. E' autore di oltre 200 articoli. Nel 2002 Coordinatore nazionale del progetto PRIN protocollo 2002074251 e nel 2009 coordinatore d'unità di progetto EFSA 2009 CFP/EFSA/CONTAM/2009/01.

Eriberto De Munari

ARPA

Laureato in chimica svolge la sua attività in campo ambientale. In Arpa Emilia-Romagna, si è occupato di inquinamento dell'aria effettuando i controlli alle emissioni degli impianti industriali e gestendo la rete di misura della qualità dell'aria della Provincia di Parma. Nel 2002 è diventato Responsabile Regionale per la Valutazione e la Gestione della Qualità dell'aria di Arpa Emilia-Romagna. Ha collaborato con la Regione Emilia-Romagna per la gestione dei piani di risanamento della qualità dell'aria e con il Ministero dell'Ambiente come tecnico esperto per la definizione di linee guida e recepimenti normativi in materia. Dal 2012 è Direttore della Sezione di Parma di Arpa. Project Manager del Progetto Europeo Life – Opera che ha ottenuto l'interesse della DG Ambiente della Commissione Europea per l'innovativo approccio sulla delicata questione della definizione dei costi del risanamento della qualità dell'aria. Dal 2011 è Professore a contratto dell'Università di Parma.

Roberto De Renzi

Dip. di Fisica e Scienze della Terra "Macedonio Melloni", Università di Parma

1979-1981, Borse di studio Della Riccia e CNR NATO Junior presso il CERN (CH).

1981-1983, Ricercatore a tempo determinato presso il Rutherford Lab. (UK) e il CERN (CH).

1983-1992, Ricercatore Universitario presso la Facoltà di Scienze di Parma.

1992-2002, Professore Associato presso la Facoltà di Ingegneria di Parma.

Dal 2002 Professore Straordinario e poi Ordinario di Fisica Generale presso la Facoltà di Ingegneria di Parma.

Coordina il Laboratorio Parma Research on Magnetism (PaRMa). Dal 1985 ha riorganizzato il laboratorio di NMR per lo stato solido del Dipartimento di Fisica di Parma.

Partecipa allo sviluppo della spettroscopia di spin muonica (muSR): i primi esperimenti esplorativi presso il CERN, (Ginevra, 1979-1987), la realizzazione di una sorgente pulsata presso ISIS (Rutherford Laboratory, 1985-1988), la consulenza scientifica per ISIS, il Paul Scherrer Institut (Villigen, CH) e J-PARC (Tokai, JP).

Nel 2012 è stato Direttore del DiFeST, nel 2010 - 2012 Direttore del Dipartimento di Fisica e da luglio 2012 è Direttore del Dipartimento di Fisica e Scienze della Terra.



Elisa Molinari

Centro di Ricerca su nanostrutture e biosistemi su superfici (S3), Istituto di Nanoscienze, CNR (Modena)

Professore Ordinario di Fisica della Materia presso l'Università di Modena e Reggio Emilia, è stata membro del personale di ricerca presso il CNR - Istituto "OM Corbino" di Roma (1986-1992), e ricercatore associato presso il Max-Planck-Institut für Festkörperforschung a Stoccarda e Grenoble (1983-1985). E' stata Direttore dell'Istituto Italiano per la Fisica della Materia (INFM) da 2007 al 2010. E' stata Segretario Generale Associato dell'Unione Internazionale di Fisica Pura e Applicata (IUPAP) e membro IUPAP del gruppo di lavoro *Women in Physics*. Ha rappresentato l'Italia nel pannello del 7FP su NMP (Nano, Materiali e Produzione) e nel gruppo di lavoro OCSE sulle nanotecnologie. E' membro delle Società di Fisica Italiana ed Europea e *Fellow* della *American Physical Society*. I suoi principali interessi di ricerca riguardano la nanoscienza e la nano(bio)tecnologia.

Cecilia Monticelli

Dip. di Ingegneria, Università di Ferrara

E' Professore Associato di Scienza dei Materiali e Tecnologie presso il Dipartimento di Ingegneria dell'Università di Ferrara e appartiene al Centro di Studi sulla Corrosione e Metallurgia "A. Daccò". I suoi interessi scientifici riguardano la protezione contro la corrosione di leghe metalliche in ambienti diversi, la corrosione in calcestruzzi tradizionali e innovativi, la corrosione e protezione dei beni culturali e la tribocorrosione di materiali ceramici elettroconduttivi per applicazioni biomediche. Appartiene alla Rete dell'Alta Tecnologia della Regione Emilia Romagna attraverso due laboratori: TekneHub (Piattaforma Costruzioni) e Terra & Acqua Tech (Piattaforma Energia e Ambiente). E' membro del comitato tecnico per la corrosione di AIM (Associazione Italiana Metallurgia). Nel giugno 2015, è stata coordinatrice della XI edizione delle Giornate Nazionali di Corrosione e Protezione. Dal 2015 è coordinatrice locale del progetto europeo biennale B- IMPACT (*Bronze-IMproved non-hazardous PATina CoaTings*) della *Call 2013* di M-ERA.NET.

Montanari Angela

SSICA, Parma

Responsabile del Dipartimento Imballaggi della Stazione Sperimentale Industria Conserve Alimentari (SSICA). Coordina l'attività di ricerca e di servizio relativa alla compatibilità tra contenitori e prodotti alimentari. Ha condotto numerose ricerche relative al miglioramento della resistenza alla corrosione e delle proprietà protettive delle vernici di nuovi tipi di materiali impiegati nell'imballaggio di alimenti. Il lavoro di ricerca ha riguardato anche la resistenza alla corrosione di materiali impiegati nella costruzione di impianti alimentari. Da ultimo si occupa di imballaggi flessibili, in particolare di imballaggi attivi e di origine naturale da fonti rinnovabili o da scarti industriali. E' coordinatore di diversi progetti europei e titolare di brevetti. E' stata membro del Gruppo di lavoro del Ministero delle Attività produttive sulla classificazione delle sostanze chimiche (REACH). E' membro del gruppo di esperti accreditato presso il Ministero dello Sviluppo Economico.



Antonio Mutti

Dip. di Medicina Clinica e Sperimentale, Università di Parma

Si è specializzato con lode in Medicina del Lavoro nel 1977 e ha svolto la sua carriera interamente nella Facoltà di Medicina e Chirurgia dell'Università di Parma, che nell'aprile 2000 lo ha chiamato a ricoprire un posto di ruolo di professore di prima fascia di Medicina del Lavoro e presso cui è Direttore del Dipartimento di Medicina Clinica e Sperimentale. E' titolare di diversi insegnamenti presso il corso di laurea in Medicina e Chirurgia, le Scuole di Specializzazione in Medicina del Lavoro, Medicina Interna e Radioterapia e il Corso di Laurea per le Professioni Biomediche in Tecniche di Laboratorio Biomedico. Direttore dell'Unità Operativa Complessa di Medicina del Lavoro e Tossicologia Industriale, è membro del *Board* per la Ricerca dell'Azienda Ospedaliero-Universitaria di Parma. Membro di diverse società scientifiche, dal 1989 ha più volte collaborato come consulente o esperto con la Commissione Europea e, come Consigliere temporaneo, con l'Organizzazione Mondiale della Sanità. Dal 2006 al 2012 è stato membro del *Panel* sui Contaminanti della catena alimentare dell'EFSA. Autore di oltre 400 pubblicazioni scientifiche, metà delle quali su riviste internazionali, è membro del Comitato di redazione di diverse riviste scientifiche del settore.

Patrizia Santi

Dip. di Farmacia, Università di Parma

Laureata in Chimica e Tecnologia Farmaceutiche nel 1987 presso la Facoltà di Farmacia dell'Università di Parma, ha conseguito il titolo di Dottore di Ricerca in Chimica e Tecnologie Farmaceutiche nel 1992. Dal 1991 al 1998 è stata Ricercatore Universitario; dal 1998 al 2002 è stata Professore Associato e dal 2002 è Professore Ordinario presso la Facoltà di Farmacia dell'Università di Parma. Dal luglio 2012 è Direttore del Dipartimento di Farmacia della medesima Università. E' autrice di più di 100 lavori sperimentali pubblicati su riviste internazionali, di brevetti, di capitoli di libri, di relazioni ad invito e seminari. L'attività di ricerca si è concentrata principalmente sulla somministrazione di farmaci per via transdermica, inalatoria, buccale, nasale, oculare e orale.

Stefano Selleri

Dip. di Ingegneria dell'Informazione, Università di Parma

Si è laureato in Ingegneria Elettronica con lode all'Università di Bologna nel 1991. Dottorato in Tecnologie dell'Informazione presso l'Università di Parma; ricercatore dal 1997 al 2002. Dal 2002 è Professore Associato presso la Facoltà di Ingegneria. Dal 2003 è titolare del corso di Propagazione Guidata, di Microonde e di Componenti Fotonici B presso la Facoltà di Ingegneria e di Campi Elettromagnetici presso la Facoltà di Medicina e Chirurgia.

E' autore di libri e monografie e di oltre 150 articoli e memorie internazionali, di relazioni ad invito e seminari, membro di numerosi comitati tecnici e commissioni di laurea e dottorato, in Italia e all'estero, revisore di riviste scientifiche del settore e IEEE *Senior Member*.



Luca Vincetti

Dip. di Ingegneria "Enzo Ferrari", Università di Modena e Reggio Emilia

Ha ricevuto la Laurea in Ingegneria Elettronica (con lode) presso l'Università di Parma, nel 1996 discutendo una tesi sullo sviluppo di metodi di propagazione del fascio basati sul metodo degli elementi finiti (FEM-BPM) per l'analisi di dispositivi ottici. Da giugno ad agosto 1996 è stato coinvolto nel progetto "Fluoroaluminato Amplifiers for Second Telecom window" (FAST), nel quadro del programma *Advanced Communications Technologies and Services*. Ha conseguito il Dottorato di ricerca presso il Dipartimento di Ingegneria dell'Informazione (DII) dell'Università di Parma nel 2000. Nel 2000 è stato ricercatore presso il CNR per le Telecomunicazioni (CNIT). Dal luglio 2001 all'ottobre 2014 è stato ricercatore di Campi Elettromagnetici presso la Facoltà di Ingegneria, Dipartimento di Ingegneria dell'Informazione dell'Università degli Studi di Modena e Reggio Emilia. Dal novembre 2014 è Professore Associato presso il Dipartimento di Ingegneria "Enzo Ferrari" dell'Università di Modena e Reggio Emilia. Attualmente la sua attività di ricerca è incentrata sullo sviluppo di fibre microstrutturate e a cristalli fotonici, guide dielettriche per sistemi THz, antenne per sistemi di identificazione a radio frequenza ed *energy harvesting*.

Marco Vitale

Dip. di Scienze Biomediche, Biotecnologiche e Traslazionali - S.Bi.Bi.T., Università di Parma

1988, Diploma di Specialità in Ematologia, *summa cum laude*.

1992, Diploma di Specialità in Tecnologie Biomediche.

1986, *Visiting scientist* presso il Department of Microbiology and Immunology, New York Medical College, NY, USA.

1994-95, *Visiting scientist* presso il Kimmel Cancer Center, Philadelphia, USA.

1992-2000, Professore Associato di Anatomia Umana, Facoltà di Medicina e Chirurgia, Università di Brescia.

Dal 2000, Professore Ordinario di Anatomia Umana, Facoltà di Medicina e Chirurgia, Università di Parma.

Preside vicario, Facoltà di Medicina e Chirurgia, Università di Parma.

Presidente del Corso di Laurea in Scienze delle Attività Motorie, Sport e Salute, Università di Parma.

Presidente del Corso di Laurea Magistrale in Scienze e Tecniche delle Attività Motorie Preventive e Adattate, Università di Parma.

Direttore del Dipartimento di Anatomia, Farmacologia e Scienze Medico-Forensi, Università di Parma

Direttore del Centro/Ambulatorio di Morfologia, Biometria e Composizione Corporea (CMBC).

E' *referee* per riviste internazionali di settore ed autore di più di 100 lavori scientifici *in extenso* con *referee board*, sui seguenti argomenti: citochine ad attività antitumorale, progenitori ematopoietici, trasduzione del segnale, apoptosi, attivazione piastrinica, antropometria, biometria.



Programma



GIOVEDÌ 3 DICEMBRE 2015

8:30-9:00 Registrazione dei partecipanti ed esposizione poster

9:00-9:30 Apertura Workshop: intervengono gli organizzatori, Prof. Nelson Marmioli e Prof. Salvatore Iannotta. Saluti delle autorità

9:30-12:30 Tavola rotonda.
Le nanotecnologie e i nanomateriali nel nostro futuro tra innovazione e sostenibilità

Le nanotecnologie pervadono ormai ogni settore della nostra vita quotidiana, con diversi prodotti che contengono o si basano sull'impiego di nanomateriali. L'innovazione porterà a nuove applicazioni che saranno illustrate nel corso del convegno, ma ci si chiede quali siano le prospettive in Italia e nel contesto internazionale per chi fa ricerca e per chi lavora con i nanomateriali, e se ci possono essere ancora dei dubbi su un loro impiego sicuro e sostenibile. E' importante che la ricerca indipendente sia a diretto contatto dei consumatori e che ci sia una corretta informazione su benefici ed eventuali rischi per la salute umana. Visti gli enormi benefici pronosticati, le nanotecnologie rappresentano un settore importante in cui i nostri giovani potranno misurarsi.

Su questi argomenti interverranno, tra gli altri:

Prof. Giovanni Franceschini, Pro Rettore vicario, Università di Parma
Dott.ssa Simona Caselli, Assessore all'agricoltura, caccia e pesca, Regione Emilia-Romagna
Prof. Jason White, The Connecticut Agricultural Experiment Station, USA
Ing. Giovanni Baroni, Unione Parmense Industriali
Dott. Andrea Zanlari, Camera di Commercio, Presidente
Dott.ssa Isabella De Angelis, Istituto Superiore di Sanità
Dott.ssa Serena Borgna, APRE
Dott. Mauro Varasi, Finmeccanica Group
Dott. Alessio Malcevschi, Delegato per la Sostenibilità, Università di Parma
Prof. Antonio D'Aloia, Ordinario di Diritto costituzionale, Università di Parma

E' previsto un *coffee break* dalle 10:30 alle 11:00

12:30-14:30 Pausa pranzo e visione poster



14:30-17:00 Sessione I. Applicazioni e tecnologie

Chair: Prof.ssa Maria Careri, Dip. Di Chimica, Università di Parma; Prof. Luca Vincetti, Dipartimento di Ingegneria "Enzo Ferrari", Università di Modena e Reggio Emilia

14:30-15:00 Miniplenary I

Prof. Andrea Zappettini, *IMEM-CNR (Parma)*. **Functional nanostructures for technology applications**

Prof. Luca Prodi, *Dip. di Chimica (Università di Bologna)*. **Light and silica nanoparticles for nanomedicine**

15:00-17:00 Presentazioni scientifiche*

15:00-15:15 Irene Bassanetti. **CO₂ uptake studies on light-responsive Porous Molecular Crystals**. *Dip. di Scienze dei Materiali, Università di Milano-Bicocca; Dip. di Chimica 'G. Ciamician', Università di Bologna; Dip. di Chimica, Università di Parma*

15:17-15:32 Erika Iveth Cedillo-González. **An insight in the influence of temperature, humidity and incident UV light on the performance of TiO₂ coatings using the design of experiments approach**. *Dip. di Ingegneria "Enzo Ferrari", Università di Modena e Reggio Emilia; Dip. di Scienze e Metodi per l'Ingegneria, Università di Modena e Reggio Emilia*

15:34-15:49 Maurizio Culiolo. **Carbon fibers functionalized with piezoelectric ZnO nanorod for mechanical stress sensing**. *IMEM-CNR, Parma; BERCELLA Srl; Dip. di Fisica e Scienze della Terra, Università di Parma*

15:51-16:06 Sjarhei Kurhuzenkau. **Linear and nonlinear optical properties of fluorene-based organic nanoparticles**. *Dip. di Chimica, Università di Parma; Dept. of Chemistry, University of Central Florida; College of Science and Liberal Arts, New Jersey Institute of Technology; CREOL, The College of Optics and Photonics, University of Central Florida; Institute of Physics, National Academy of Sciences of Ukraine*

16:08-16:23 Daniele Pontiroli. **Graphene based Li- and Na-ion batteries**. *Dip. di Fisica e Scienze della Terra, Università di Parma; University of New South Wales, Australia; Dip. di Chimica, Università di Pavia*

16:25-16:40 Luca Romoli. **Experimental study on the production of flat metal surfaces with enhanced asepticity by ultrashort-pulsed laser nanopatterning**. *Dip. di Ingegneria Industriale, Università di Parma; Dip. di Ingegneria dell'Informazione, Università di Parma*

16:42-16:57 Federica Zanotto. **Improving the corrosion protective properties of silane coatings for outdoor bronzes by addition of oxidic nano- and microparticles**. *Centro di Studi sulla Corrosione e Metallurgia "A. Daccò", Università di Ferrara*

17:00-17:30 *Coffee break e visione poster*

17:30-18:30 Conferenza stampa

18:30-19:00 Conclusioni generali della prima giornata



VENERDÌ 4 DICEMBRE 2015

9:00-12:30 **Sessione II. Agroalimentare, Ambientale, Biotecnologie**

Chair: Prof.ssa Angela Montanari, SSICA, Parma; Prof.ssa Marta Marmioli, Dip. di Bioscienze, Università di Parma

9:00-9:30 **Miniplenary II**

Prof. Michele Suman, *FOODINTEGRITY EU project. Integrated capability for detecting frauds and assuring the integrity of the food chain*

Prof. Jason White, *Department of Analytical Chemistry, The Connecticut Agricultural Experiment Station, New Haven, USA. Nanotechnology and the environment: applications and implications*

9:30-12:30 **Presentazioni scientifiche***

9:30-9:45 Katia Carbonara. **Nanofossils: what is essential is invisible to the eye.** *Dip. di Fisica e Scienze della Terra, Università di Parma*

9:48-10:03 Nicola Coppedè. **Biosensing transistors to monitor *in vivo* tomato plant lymph.** *IMEM-CNR, Parma; Dip. di Bioscienze, Università di Parma*

10:06-10:21 Michele Cordioli. **Spatial and indoor/outdoor gradients in urban concentrations of PM2.5 mass and ultrafine particles.** *ARPA Emilia Romagna; Dip. di Scienze e Alta Tecnologia, Università dell'Insubria; Consorzio Interuniversitario Nazionale per le Scienze Ambientali (CINSA)*

10:24-10:39 Davide Imperiale. **An integrated multi-“omics” approach to understand CdS Quantum Dots (CdS QDs) response in *Arabidopsis thaliana* mutants.** *Dip. di Bioscienze, Università di Parma; SITEIA.Parma; IMEM-CNR, Parma*

10:42-10:57 Riccardo Muzzi. **Bioluminescent engineered *Escherichia coli* strains for testing of carbon nanotubes toxicity.** *Dip. di Scienze degli Alimenti, Università di Udine; Laboratoire de Nanotechnologie et d'Instrumentation Optique, Institute Charles Delaunay, Université de technologie de Troyes, France; Department of Biotechnology Engineering, Faculty of Engineering Science, Ben-Gurion University of the Negev, Beer-Sheva, Israel; School of Material Science and Engineering, Nanyang Technology University, Singapore; Ben-Gurion University of the Negev, Beer-Sheva, Israel*

11:00-11:30 **coffee break**

11:30-11:45 Luca Pagano. **Nanomaterials and crop plants: health and environmental safety related to molecular effects of ENMs exposure.** *UMASS, Amherst, MA, USA; The Connecticut Agricultural Experiment Station, New Haven, CT, USA; Dip. di Bioscienze, Università di Parma*

11:48-12:03 Priya Vizzini. **Construction and optimization of an optical biosensor based on LSPR for the detection of *Brettanomyces bruxellensis*.** *Dip. di Scienze degli Alimenti, Università di Udine; School of Microelectronics and Solid-State Electronics, Univ. of Electronic Science and Technology of China, Chengdu, China; Lab. de Nanotechnologie et d'Instrumentation Optique, Institute Charles Delaunay, Université de Technologie de Troyes, France*



12:06-12:21 Serena Zanzoni. **The study of transient ubiquitin-nanoparticle interactions by solution NMR spectroscopy.** *Dip. di Biotecnologie, Università di Verona; Center for Biomolecular Structure and Organization, Department of Chemistry and Biochemistry, University of Maryland, College Park, Maryland, USA*

12:30-14:30 Pausa pranzo e visione poster

14:30-17:15 **Sessione III. Salute e benessere**

Chair: Prof.ssa Patrizia Santi, Dip. di Farmacia, Università di Parma; Prof. Marco Vitale, Dip. di Scienze Biomediche, Biotecnologiche e Traslazionali, Università di Parma

14:30-15:15 **Miniplenary III**

Prof. Enrico Bergamaschi, *Dip. Medicina Clinica Sperimentale (Università di Parma)*. **Health effects of nanomaterials**

Dott. Michele Bianchi, *Istituto Ortopedico Rizzoli (Bologna)*. **Nano-biomaterials in the orthopaedic field**

Prof. Dario Dalla Vedova, *CONI*. **Olimpic sport: sensor evolution and new challenges**

15:15-17:15 **Presentazioni scientifiche***

15:15-15:30 Kristel Martinelli. **A new-generation cell Selector for the standardization of a regenerative medicine product.** *STEM SEL Srl; Banca delle Cellule e del Tessuto Muscoloscheletrico (BCTM), e Laboratorio Prometeo, Istituto Ortopedico Rizzoli, Bologna; Dip. di Chimica "G. Ciamician" e Dip. di Medicina specialistica, diagnostica e sperimentale", Università di Bologna*

15:32-15:47 Valentina Marassi. **Tools for drug development: isolation, characterisation and quantification of nanosystems.** *BYFLOW Srl; Dip. di Chimica "G. Ciamician", Università di Bologna; CRANN/AMBER; Department of Clinical Medicine, Trinity College Dublin, Ireland*

15:49-16:04 Fabio Sonvico. **Biodegradable Nanoparticles: a Pharmaceutical Nanotechnology Platform for the Delivery of Poorly Soluble Drugs.** *Dip. Farmacia e Dip. di Fisica e Scienze della Terra, Università di Parma*

16:06-16:21 Manfredi Allegri. **Pro-inflammatory effects of pyrogenic and precipitated amorphous silica nanoparticles in innate immunity cells.** *Dip. di Medicina Clinica e Sperimentale e di Scienze Biomediche, Biotecnologiche e Traslazionali, Università di Parma; Dip. di Medicina Sperimentale Clinica, Università di Parma; School of Medicine, Trinity College Dublin, Ireland; Advanced Microscopy Laboratory, Trinity College Dublin, Ireland; Joint Research Centre, Institute for Health and Consumer Protection, Ispra, Italy*



- 16:23-16:38** Andrea Buccarello. **Diesel Exhaust Particulate derived from Euro3 and Euro4 engines modulates cardiac electrophysiology and enhances arrhythmias.** *Dip. di Medicina Sperimentale Clinica, Dip. di Fisica e Scienze della Terra; Dip. di Bioscienze, Università di Parma; INAIL*
- 16:40-16:55** Joana Gjipalaj. **Nano- and microporous ceramic beads for efficient adsorption of Cr(VI) from water.** *Dip. di Ingegneria Meccanica e Industriale, Università di Brescia; Advanced Ceramics, University of Bremen, Germany; Petroceramics S.p.A.*
- 16:57-17:12** Marta Giuliani. **Hybrid liposomes decorated with glucocalix[4]arenes for targeted drug delivery.** *Dip. di Chimica, Università di Parma; Dip. di Chimica, Università "La Sapienza", Roma; Dip. di Tecnologie e Salute, Ist. Superiore Sanità, Roma; CNR, Istituto di Metodologie Chimiche, Roma*

17:15-18:30 **Coffee break e discussione poster**

Chair: Prof. Roberto De Renzi, Dip. di Fisica e Scienze della terra, Università di Parma; Prof.ssa Elisa Molinari, Dip. di Scienze Fisiche, Informatiche e Matematiche, Università di Modena e Reggio Emilia; Prof. Stefano Selleri, Dip. di Ingegneria dell'Informazione, Università di Parma; Prof.ssa Cecilia Monticelli, Dip. di Ingegneria, Università di Ferrara; Dott.ssa Roberta Ruotolo, Dip. di Bioscienze; Dott. Eriberto De Munari, ARPA

18:30-19:00 **Conclusione dei lavori**

**Nelle presentazioni orali è indicato solo il nome del giovane ricercatore presentante*



Comunicazioni orali



CO₂ uptake studies on light-responsive Porous Molecular Crystals

Irene Bassanetti^{a,c,#}, Angiolina Comotti^a, Piero Sozzani^a, Massimo Baroncini^b, Simone d'Agostino^b, Fabrizia Grepioni^b and Alberto Credi^b

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In the fascinating world of nanoporous materials¹, Porous Molecular Crystals (PMC)² have attracted increasing attention for their responsive capabilities to external stimuli. The modification of their architectures is in fact associated to a change in their chemico-physical features. Their frameworks are based on intermolecular weak interactions, which results from the assembly of discrete molecules in energetically convenient crystal packing. PMC have interesting applications ranging from catalysis, adsorption, separation to an increasing number of emerging technologies. Our strategy³ was based on introducing azobenzene groups (well-known for their photoisomerization) into a star-shaped tetrahedral C-centered molecule to obtain molecular crystals endowed with permanent porosity. The crystals with azobenzene in E configuration (E₄-1c compound) showed a maximum CO₂ molecular uptake value of 41 cm³g⁻¹ at 10 bar and 273 K. Thanks to photoisomerization (E→Z conversion), it was possible to modify the E isomer porous structure into the tightly packed arrangement of the Z isomer. In fact, the CO₂ adsorption isotherms for the Z isomers showed a negligible adsorption. By thermal isomerization, the Z isomers interconverted again into the porous E isomer, and pointing to a reversible adsorption/desorption gas-uptake. Quantitative information on the solid-state photoisomerization were obtained through PXRD on a thin film of E₄-1c on a quartz slide. After prolonged irradiation at 365 nm, the intensity of all peaks decreased up to disappear, indicating the conversion to the amorphous (Z isomer). The PXRD signals were then restored after proper heating of the irradiated film, confirming the reversibility of the phase change in the solid state.

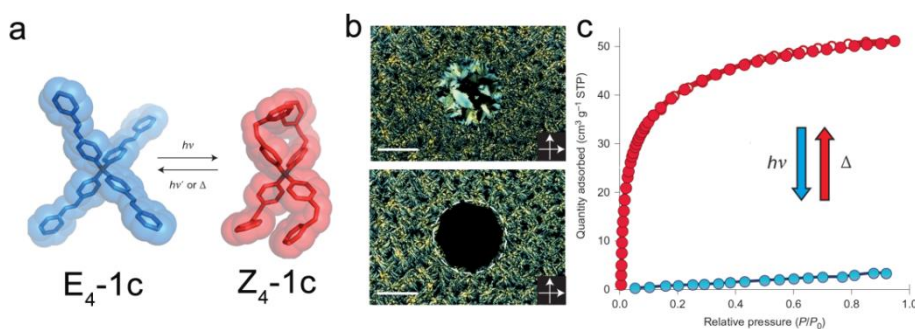


Fig. 1 a) Schematic representation of E→Z conversion b) Cross-polarized optical photomicrographs of solid E₄-1c after UV irradiation in a central spot (down) for 10 min and after thermal annealing at 160°C for 20 min (up). In c) CO₂ adsorption isotherms at 195K of E₄-1c (red circles) and Z₄-1c (blue circles).

[1] A.Slater, A.Cooper. *Science*, **2015**, 348(6238), 8075-1-10.

[2] I.Bassanetti, A.Comotti, P.Sozzani, S.Bracco, G.Calestani F.Mezzadri, L.Marchiò. *JACS*, **2014**, 136, 14883-14895.

[3] M.Baroncini, S.d'Agostino, G.Bergamini, P.Ceroni, A.Comotti, P.Sozzani, I.Bassanetti, F.Grepioni, T.M.Hernandez, S.Silvi, M.Venturi, A.Credi. *Nature Chemistry*, **2015**, 7, 634-640.

An insight in the influence of temperature, humidity and incident UV light on the performance of TiO₂ coatings using the design of experiments approach

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The ability of TiO₂ to photo-oxidize pollutants when irradiated with UV light has led it to become the key component of materials with photocatalytic self-cleaning characteristics. The research in this field has revealed that the efficiency of TiO₂ depends of three groups of factors: (i) those correlated with the coating itself (i.e., microstructure, surface area, etc.); (ii) those correlated with the target pollutant and (iii) those correlated with the environment (i.e., temperature, humidity and incident light). Most of this research has been performed using the traditional approach, revealing only the correlation between the efficiency and one factor at time (one-factor at time approach). However, evidences found in our previous works suggest that the efficiency of TiO₂ does not only depend of single factors but also of the interactions between them (i.e., temperature/humidity, temperature/incident light, etc.). In this work, the design of experiments (DoE) approach was used to study in a systematic way the photocatalytic activity of two TiO₂ coatings with different microstructure. Particularly, the effect of temperature, humidity and incident UV light were explored in terms of stearic acid (SA) degradation. The obtained results revealed that single factors such as temperature and microstructure have the strongest influence in the efficiency of the coatings. However, it was also found that the interaction factor temperature/incident UV light affects the activity of both coatings and this phenomenon depends of their grade of hydration before the deposition of SA.



Carbon fibers functionalized with piezoelectric ZnO nanorod for mechanical stress sensing

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Carbon fiber composites (CFC) represent a fundamental technology for mechanical applications. Due to the intense mechanical stress involved, deformation on CFC structures have to be constantly monitored.

Nowadays strain sensing on CFC is carried out through optical fiber and piezoelectric ceramics. However these technologies present three main drawbacks: large size (compared to CF), weight addition and use of precious metal wires. Recently the use of piezoelectric ZnO nanostructures started to get a foothold for sensing and energy harvesting.

Piezoelectric effect, owing to its dual peculiarity relating deformation with electric properties, lends itself to both sensing and actuating applications. Therefore functionalization of CF with ZnO piezoelectric nanostructures allow to realize a fully integrated piezoelectric sensor/actuator within CFC structure, thanks also to the fact that conductive CF themselves act as electrical wires.

The ZnO growth is made by a low-temperature and low-cost two-step process:

1. growth of ZnO seed-layer by SILAR technique;
2. growth of ZnO nanorods by chemical bath deposition.

Measuring the piezoelectric effect in ZnO nanostructures is still a debatable topic, since the typical I-V characterization is not generally accepted. In this work piezoelectric investigation is carried out for the first time on this type of structure using DHM technique and capacitance measurements. When a stress is applied, a strong capacitance increase occurs. Under specific frequency conditions, this is ascribed as the fingerprint of piezoelectricity.

During this work, in collaboration with the CFC manufacturer Bercella Srl in Varano de' Melegari (Parma), an international patent was registered and published.

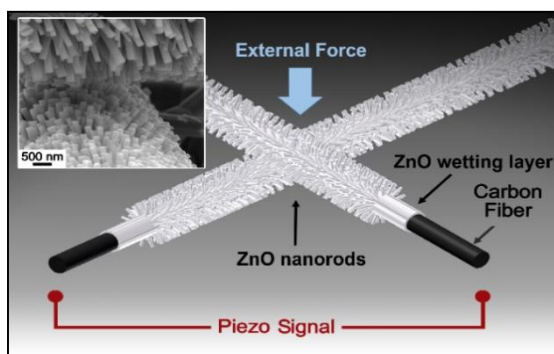


Figure 1. Depiction of the device structure and working principle.

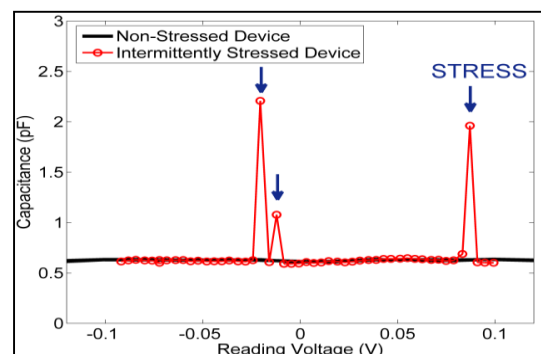


Figure 2. Comparison between capacitance of unstressed and stressed device.

Linear and nonlinear optical properties of fluorene-based organic nanoparticles

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Two-photon microscopy (2PM) is a powerful tool for biomedical research and deep tissue imaging but it requires fluorescent labels with specific properties: hydrophilic with high photochemical stability and high fluorescence brightness. However a part of widely used as well as newly synthesized dyes for 2PM are water insoluble and several strategies of solubilization exist. One of the approaches is based on the reprecipitation method that allows to disperse hydrophobic dye in water in form of nanoparticles (ONPs). The reprecipitation method is convenient and effective way of preparing ONPs by solvent exchange process.

The current study presents linear and nonlinear optical properties of ONPs synthesized from new fluorene derivative S1 (3,3'-(2-(benzo[d]thiazol-2-yl)-7-(diethylamino)-9H-fluorene-9,9-diyl)dipropenenitrile). After rapid injection of concentrated S1 solution in THF into water dye molecules begin to aggregate and form fluorescent nanoparticles with narrow size distribution and average diameter of ~160 nm. Absorption spectra of the suspension is broadened and red-shifted compared to the absorption of the monomeric dye solution in organic solvents and maximum appears around 410 nm. Fluorescence spectra of S1 ONPs shows large Stokes shift with emission peak at about 510 nm. The degenerate two-photon absorption spectra of S1 ONPs was measured in a wide spectral range by two-photon excited fluorescence technique using femtosecond excitation pulses. Obtained data prove good prospects for using S1 ONPs in nonlinear photonics and bioimaging applications.

The research leading to these results has received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/ under REA grant agreement №607721.



Graphene based Li- and Na-ion batteries

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Nowadays, rechargeable Li-ion batteries (LIBs) represent the state-of-the-art for the power supply in technological devices. However, the wide-scale implementation of this technology, for example in the automotive field, raises some issues, concerning, for example, the still low performances achievable by the current devices, or the high costs needed, due to the limited lithium mineral reserves. The investigation of new materials as components for new batteries, capable, on the one hand, to provide better performance than the current commercial systems and, on the other hand, to allow the exploitation of alternatives to lithium, is hence highly desirable.

In this framework, novel carbon nanomaterials, such as graphene-based materials, appear very good candidates. In the Carbon Nanostructures Laboratory, Department of Physics and Earth Sciences (CNL, <http://www.difest.unipr.it/nanocarbon>), we managed to produce gram-scale graphene, by means of chemico-physical methods. This material, in virtue of its high porosity, electronic and mechanical properties, has shown very good performances as anode of high-capacity LIBs. Recently, we also found that anodes based on graphene derivatives can also support the insertion of Na⁺ ions with high capacity and stability upon cycling. In particular, performances are strongly enhanced when graphene is decorated with Ni-nanoparticles.

These findings indicate the feasibility of the development of novel Na-ion batteries (NIBs), whose research is still at an early stage, because of the lacking of suitable Na anode materials. NIBs are expected to be good candidates for large scale grid storage applications, thanks to the wide availability and low cost of Na.



Experimental study on the production of flat metal surfaces with enhanced asepticity by ultrashort-pulsed laser nanopatterning

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Fluid-repellent and antibacterial metal surfaces can be achieved by the development of a novel industrial use of high-average power ultrashort-pulsed lasers by preventing the deposition of liquid layers as for the well-known phenomenon of the lotus leaf. With the main purpose of producing self-cleaning and aseptic machine parts for food industry (e.g. components in contact with biological fluids) and home appliances (e.g. dishwashers), a novel method of beam delivery over areas that can reach 250 mm² is tested and optimized.

The conceptual design of laser-textured surfaces foresees morphology features with a periodicity in the range of 1-10 μm filled by nanoripples. Surface structures down to the nanoscale can be obtained by two different laser processing: Direct Laser Interference Patterning (DLIP) and Laser Induced Periodic Surface Structuring (LIPSS). High-pulse energies with large focal spot and high repetition rate with small focal spot are tested to generate surface patterns in accordance to previously defined design criteria. A parametric optimization of the optical devices and the beam delivery systems is performed and the accuracy and the repeatability of a high throughput production of structures in the μm range is assessed over large incidence areas. At this concern, flat samples are produced in order to understand and characterize the interaction phenomena with the selected fluids. The antibacterial properties are verified to guarantee a severe asepticity which should be comparable to that obtainable by chemical layers or by coatings doped with silver nanoparticles.



Improving the corrosion protective properties of silane coatings for outdoor bronzes by addition of oxidic nano- and microparticles

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The conservation of the artistic heritage is of great importance because it allows the preservation of the historical and cultural identity of a society for the benefit of present and future generations. Both ancient and modern bronze artworks are an important part of this cultural heritage and the development of effective and environmentally satisfactory protective treatments is an important and still unresolved issue. Organosilane coatings attracted a significant research attention in recent years, for the protection of several metallic alloys and a few silane coatings were tested also on copper and copper alloys. It was assessed that 3-mercaptopropyl-trimethoxysilane (PropS-SH) coatings can offer outstanding corrosion protective properties in different aggressive environments, but the scattering of the coating performances is unexpectedly high.

This research (within the B-IMPACT Project (Bronze-IMproved non-hazardous PATina CoaTings of the M-ERA.NET 2013 call) aims at evaluating the influence of some parameters on PropS-SH coating performances against bronze corrosion in a concentrated synthetic acid rain. In particular, the tests investigate the influence of some oxidic nano- and microparticle addition, the time of permanence of these particles in the hydrolized silane solution prior to the coating application, the reticulation conditions before exposure to the aggressive solution and the possibility to conserve and reuse the hydrolized silane solution.

The techniques adopted involve electrochemical tests performed during 20 day exposures, in order to monitor the corrosion processes and assess the efficiency of surface treatments. On selected specimens, the nature of the surface corrosion products are analysed by FTIR spectroscopy and SEM-EDS observations.



Nanofossils: what is essential is invisible to the eye

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Calcareous nanofossils [nano (Greek)= dwarf] are an exceptional microfossil group, with living counterparts, Coccolithophores. In today's oceans, they are one of the most important marine primary producers, despite their small size. Individual coccoliths are usually between 5 and 10 microns. A coccolith is a single disc-like calcitic plate, secreted by the algal organism. On death the individual coccoliths become separated and they are commonly preserved in the sedimentary record.

This phytoplankton forms the basis of the marine food chain and plays an important role in geochemical cycles: it affects the carbon and oxygen cycles by secreting coccoliths and by producing organic matter during photosynthesis ("biological pump"). Both processes influence the oceanic and atmospheric concentrations of the greenhouse gas CO₂. Moreover, Coccolithophores emit dimethylsulphoniopropionate (DMS) which is converted to dimethylsulphide (DMS), one of the most important cloud condensation nuclei that, in turn, affects the albedo. These factors underline the importance of calcareous nanofossils for the Earth's biogeochemical cycles and the climate system.

The study of Coccolithophores has flourished since the 1960's. The Deep Sea Drilling Project (DSDP) brought the stratigraphic value of calcareous nanofossils to the attention of industry as well as the scientific community. Research on calcareous nanofossils in the past provides important clues for palaeoceanography and palaeoclimatology. Today calcareous nanofossils have become the preferred tool for quick accurate stratigraphic age determination in calcareous sequences.

The palaeoecological nanofossil assemblage variations can help to frame the palaeoclimatic and palaeoceanographic events of a studied area.



Source: www.fishlarvae.com

Biosensing Transistors to Monitor In-vivo Tomato Plant Lymph

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Plants, like all the living beings, are a complex system where bio-chemistry reactions plays a fundamental metabolic role in wellness of their organism. In the last years, the topic of an instrumental objective control, on the physiological characteristic of the living plants, have grown interest in the scientific community. The control on food plants during their growth, in non-invasive and low cost way, is a crucial challenge, strictly related to safety and healthiness in agriculture, which allows optimization of the nutrients and reduction of pesticides. Different attempt to apply analytical chemistry techniques to study a wide range of parameters related to the plant metabolism (pH, radicals, ions, proteins, ROS) have been realized [1]. Nevertheless, it is often necessary to extract samples from the plant and analyze them by means of an external system (HPLC, GC, spectrometry). While the introduction of invasive electrodes and sensors still maintain a limited applicability [2]. An innovative way to analyze the biochemical active parameters of a living plant is to take advantage of organic electrochemical sensing. In this work, we approach the introduction of sensors based on the natural fiber of silk, opportunely functionalized, to form organic biosensing transistors. The device maintains a low invasive and biocompatible structure. The functionalized silk fiber form an active channel with different possible gate electrodes. The biosensors were used to measure *in-vivo* electrical characteristics of a tomato branch, showing the sensitivity of the response to day-night cycles and to the physiological condition of the plants. The devices paves the way to low cost, in-vivo monitoring of plants biophysical conditions.

[1] Obata, T. et al. The Biochemist 37 (2015) 14-18

[2] Ren, Q. et al. Sensors and Actuators B 220 (2015) 743-748



Spatial and indoor/outdoor gradients in urban concentrations of PM_{2.5} mass and ultrafine particles

Stefano Zauli Sajani^a, Vanes Poluzzi^a, Andrea Cattaneo^b, Michele Cordioli^{a,c,#}, Nelson Marmiroli^c, Paolo Lauriola^a

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The SUPERSITE Project, financed and realized by Regione Emilia-Romagna and ARPA-ER, aims at better understanding the sources of the aerosol atmospheric pollution and its connection with human exposure and health. The WorkPackage 5 is focused on the study of the spatio-temporal variability of the relationship between indoor and outdoor (I/O) particulate air pollution in urban settings and aims at studying I/O pollution differences between (i) residential and trafficked areas, (ii) front and back on the same building, (iii) seasons in the year, (iv) different floors of the same building.

Here we present some preliminary results of the WP5, with a focus on the experiment conducted to compare I/O ratios of particulate in two similar unoccupied buildings with very different proximity to traffic. Measurements were made of I/O concentrations of PM_{2.5} and ultrafine particle (UFP, < 100 nm) number size distributions. Much larger spatial variability was found in the concentrations of UFP compared to PM_{2.5}. Mean indoor concentrations at the traffic site were higher than outdoor concentrations at the residential site. Significant differences were found for the shape of particle size distributions for outdoor particles while indoor particles showed very similar distributions. We observed a selective loss of particles in the indoor atmosphere in the size range below 50 nm, in comparison to coarser particles. I/O ratios for PM_{2.5} were higher than for UFP at both sites. Our findings represent a contribution to understanding the appropriate data to be collected in epidemiological studies on air pollution.

An integrated multi-“omics” approach to understand CdS Quantum Dots (CdS QDs) response in *Arabidopsis thaliana* mutants

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A fuller understanding of the interaction between plants and engineered nanomaterials is of topical relevance because the latter find applications also in agriculture and in food industry. The aim of this work was to develop a toxicogenomics approach to assess the risk posed by NMs using *Arabidopsis thaliana*.

In a previous study, the recognition of two independent *A. thaliana* mutants displaying a greater level of tolerance than the wild type plant to exposure to cadmium sulfide quantum dots (CdS QDs) has offered the opportunity to characterize the tolerance response at the physiological and transcriptomic levels.

Proteomic analysis has been performed on crude protein extracts, obtained from whole seedlings of the two mutants and on the wild type, grown on agarized MS, both treated with 80 mg/L CdS QDs and non-treated. Proteins with different isoelectric point (pI) and hydrophobicity have been separated by a 2D liquid chromatography technique, and an analysis using MultiVue Software has been carried out on qualitative/quantitative differentially abundant protein peaks between wild-type and mutant plants. Proteins whose abundance was statistically different in response to the experimental conditions were identified by MALDI-TOF/MS to infer their possible role in the plant response to CdS QDs, in particular resistance.

An integrated study using a global proteomic approach to understand response to nanoparticles in plants, together with physiological and transcriptomic analyses, may lead to a better understanding of some of the main genetic, molecular and physiological mechanisms at the basis of response to stress induced by CdS QDs.



Bioluminescent engineered *Escherichia coli* strains for testing of carbon nanotubes toxicity

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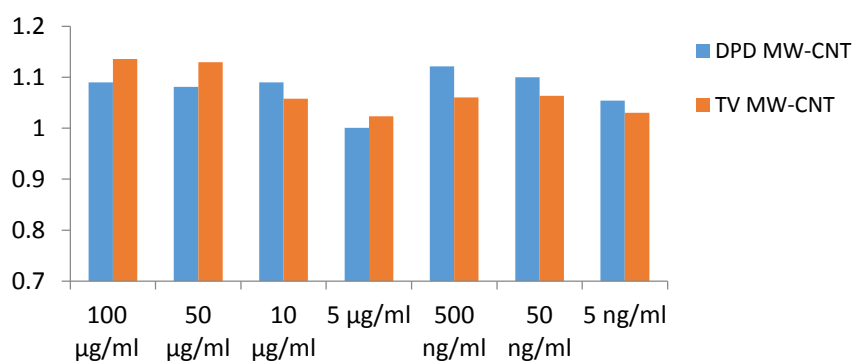
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The utilization of bacteria based biosensors for the study of toxic compounds is regarded as a key advancement for rapid and reliable detection of hazards for health and environment, such as the use of carbon nanotubes products in medicine and engineering.

In this study the toxicity of carbon nanotubes, both multi-walled and single-walled configuration, was tested using the engineered bioluminescent *Escherichia coli* TV1061 and *Escherichia coli* DPD2794. The *E. coli* TV1061 strain is sensitive to protein damage, while the *E. coli* DPD2794 strain is sensitive to DNA damage. To compare the toxicity of the carbon nanotubes a standard for comparison was created using some elements of known toxicity such as alumina, copper and nickel, in nanoparticle form. Different protocols for the interaction between bacteria and toxic agents at different concentrations, temperatures and times were tested. The bioluminescent signal given off by the bacteria was analysed with luminometer and normalized as induction factor.

Scanning electron microscope was used to evaluate cell surface modifications and damage, focusing on the interaction between nanoparticles and bacterial cells.

For both strains the luminescence damage response followed a peculiarly shaped curve, which correlated to the toxic agent concentration and the maximum luminescence in a double peak, as shown in the table below.



Comparison between the induction factors of *E. coli* DPD2794 and *E. coli* TV1061 strains at different concentrations of carbon nanotubes

Nanomaterials and crop plants: health and environmental safety related to molecular effects of ENMs exposure

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The aim of this work is to identify sensitive molecular biomarkers in agricultural crops that indicate exposure to engineered nanomaterials (ENM). Appropriate biomarkers can be used as both descriptor and predictors of exposure and effects. *In vivo* functional toxicology is already utilized for the identification of genes involved in tolerance and sensitivity to nanomaterials in model plant systems. Transcriptomic and proteomic approaches, following identification of orthologs genes (involved in metabolic functions, detoxification and stress response, transports, protein synthesis and DNA repair) across different species, can significantly augment conventional morphological and physiological data on plant response. Species amenable to such approaches include crop plants such as maize, rice, tomato or zucchini, several of which have already been investigated with regard to food safety and engineered nanomaterials. About 70 candidate/target genes identified in this way will be validated through transcriptomic/proteomic analyses. Comparative analyses of the identified target genes will lead to the selection of a panel of genes which are candidates as biomarkers of early and late effects of nanomaterial exposure. A system biology approach will allow the target genes to be linked in a complex network, representing molecular pathways, cellular components and biological processes involved in ENMs response. Some of the target genes are expected to represent biomarkers of susceptibility, which affect (modulate) the response in different genotypes or cultivars.



Construction and optimization of an optical biosensor based on LSPR for the detection of *Brettanomyces bruxellensis*

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The yeast *Brettanomyces bruxellensis*, is well-known in the oenological field for being the cause of significant defects in wine called “Brett character” that lead to consequent economic losses for the cellar.

The methods used for the microbiological analysis base on the utilization of isolation media, and molecular techniques such as PCR, nested-PCR, RFLP, FISH and dot blot that use primers, endonucleases and labelling procedures. A new approach bases on the development of nanotechnology associated with Localized Surface Plasmon Resonance (LSPR) phenomenon which can reduce the time needed to obtain results.

Nanometer scale DNA biosensors lead to several advantages such as short analysis time, minimum liquid handling and a multiple detection possibility. Moreover, the high sensitivity of LSPR have been utilized to fabricate a LSPR label-free optical biosensor in connection with gold nanoparticle substrate (Au NPs). The development of LSPR nanobiosensors for the rapid and sensitive detection of *B. bruxellensis* has been obtained by the deposition of gold nanoparticles onto a glass slide to create a surface for the immobilization of a thioled specific DNA probe (capture probe) used as bioreceptor for the target DNA molecules extracted from wine yeasts. Various protocols were designed to test different temperature and times for the immobilization of the capture probe. Moreover, several hybridization times were tested to optimize the hybridization between the complex capture probe and target DNA. Pure DNA from *B. bruxellensis* was used as positive control and pure DNA from *Saccharomyces cerevisiae* was used as negative control. A sensitivity of 10cells was obtained.



The study of transient ubiquitin-nanoparticle interactions by solution NMR spectroscopy

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The potential use of nanoparticles (NPs) in biomedical applications has attracted considerable interest in the last years. NPs introduced in a biological environment interact with a collection of biomolecules, including proteins. NPs associating with proteins may determine changes in protein conformation, interfere with protein-protein interactions, and affect signal communication pathways. Thus, particularly relevant is the study of NP-induced functional perturbations of proteins implicated in the regulation of key biochemical pathways. Ubiquitin (Ub) is a small cytosolic protein playing a central role in numerous biological processes including protein degradation, cell signaling, and DNA repair. In this respect, we characterized, at atomic level, the interactions of Ub with fullerene NPs, which are small carbon based NPs and with lanthanide (Ln)-doped fluoride NPs of 10-12 nm.

The analysis of NMR data suggested the occurrence of a reversible equilibrium between free and NP-bound protein forms and that Ub interacts specifically with both NPs. In addition we observed that fullerene and SrF₂ NPs may act similarly by binding to Ub recognition sites that are functional for intracellular communication mediated. Thus, our findings support the view that NPs may affect fundamental interaction patterns of Ub, with possible nanotoxic consequences on cell homeostasis. On the other hand, the specific inhibition of critical Ub interactions through competitive binding of NPs to polyUb chains could represent a novel potential opportunity for pharmacological intervention against cancer development.



A new-generation cell Selector for the standardization of a regenerative medicine product

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Mesenchymal stromal cells (MSCs) are immature multipotent cells that have the ability to self-renew and differentiate into several cell types. Their ability to stimulate the regeneration of damaged tissues has made them ideal for applications in regenerative medicine. The adipose tissue (AT), has proven to be a rich source of MSCs for tissue regeneration. It is also easily obtainable in large quantities and can be extracted in a non-invasive way. The purpose of this research is about the characterization of a product based on ASCs obtained through an in-flow cellular purification technology (NEEGA-DF), able to select cells basing on differences in their size and their morphological properties. This simple, fast and non-invasive technique of cell sorting, which has become a product named Celector®, is able to purify homogeneous sub-populations of ASCs, while maintaining their native properties and functions, is not changed.

What most distinguishes Celector® from other technologies, available at date on the market for the cell selection, is the possibility to select stem cells without using antibodies or any other type of tags. This advantage has two large repercussions involving both in overcoming the legislative restrictions for the use of characterized cells and free of contaminants such as markers, and in the presence and uniqueness of the markers for the populations stem, not effectively markable. Results demonstrate that Celector® cell sorting technology can be used to purify/enrich raw adipose tissue in mesenchymal stem cells. Celector® can process multiple cellular sources, including "discarded tissues" such as placenta and umbilical cord.

Tools for drug development: isolation, characterisation and quantification of nanosystems

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Flow-field flow fractionation is a soft fractionation technique able to separate particles in suspension according to their hydrodynamic radius.

Easy to be implemented to the instrumental setups often already available, it creates a powerful analytical platform for drug development purposes. It can separate samples from the nano- to the micro- scale (2-3 nm to > 80 nm). It allows for separation in native conditions, with a wide range of mobile phases (in terms of pH, salinity and viscosity); membranes/fibers are disposable and low-cost, separation can be analytical or semi-preparative.

The achievable goals with this implementation are shape, stability/formulation, ageing and aggregation study of drug compounds; evaluation, quantification and separation of bound/unbound active substance or coated/uncoated particles.

For metal nanoparticles, like silver-based antimicrobials, the amount of free ions can be quantified and the 'washed' particles can be collected and tested individually, since this technique is non-destructive, as opposed to ultrafiltration. An overview of the most successful recent applications will be presented, including pre-proteomic steps for aged related diseases' investigation and the key role of this technology for nanosafety issues.



Biodegradable Nanoparticles: a Pharmaceutical Nanotechnology Platform for the Delivery of Poorly Soluble Drugs

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Nanocarriers protect drugs, improve their aqueous solubility, promote transmucosal absorption and cellular uptake, with potential beneficial effects on drug bioavailability and efficacy.

Our research group has described a colloidal nanoparticle system obtained by interaction between the cationic polysaccharide chitosan and soybean lecithin. Such nanoparticles spontaneously form following a simple and easily scalable self-assembly process.

So far, these lecithin/chitosan nanoparticles (LCNs) have been studied as carriers for drug administration by the oral route, topical application, nasal administration and also for transdermal delivery.

In one drug loading study, LCNs were loaded with tamoxifen citrate, a drug in use for the oral treatment of oestrogen-dependent breast cancer, in order to tackle the problems related to its poor and erratic bioavailability. Interestingly, it was observed that enzymes like lipase and lysozyme trigger the release of tamoxifen citrate from LCNs by degrading the nanoparticle structure. Thus, the drug remained encapsulated and protected until the release starts due to the contact with lysozyme or lipase enzymes (Figure 1).

This biological trigger mechanism, of lecithin/chitosan nanoparticles opens the potential applicability for buccal, vaginal and nasal drug administration. In local administration, the presence of chitosan may prolong retention of formulation due to its mucoadhesive properties, thus enhancing drug permeation. At the same time the presence at mucosal level of lysozyme and other enzymes, provides the ideal trigger to maximize the drug release at the mucosal surface.

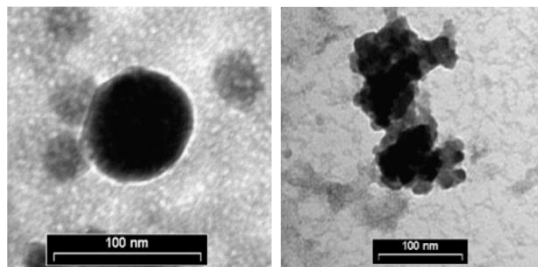


Fig. 1. TEM images of LCNs after 1 hour (SX) and 24 hours (DX) of contact with lipase enzymes

Pro-inflammatory effects of pyrogenic and precipitated amorphous silica nanoparticles in innate immunity cells

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Amorphous Silica NanoParticles (ASNP) are synthesized via several processes, two of which are the thermal route (to yield pyrogenic silica) and the wet route from a solution containing silicate salts, to obtain various nanosilica preparations, such as precipitated silica. Both methods lead to ASNP that are applied as food additive (E551). Current food regulation does not require that production methods of additives are indicated on the product label, and, thus, the ASNP are listed without mentioning the production method. The present study was aimed at clarifying if two representative preparations of ASNP, NM-203 (pyrogenic) and NM-200 (precipitated), endowed with comparable physical properties, had different effects on murine MH-S and RAW264.7 macrophages. When incubated in protein-rich fluids, NM-203 adsorbed on their surface more proteins than NM-200 and, once incubated with macrophages, elicited a greater oxidative stress, assessed from *Hmox1* induction and ROS production. Flow cytometry and helium ion microscopy indicated that pyrogenic NM-203 interacted with macrophages more strongly than the precipitated NM-200 and triggered a more evident inflammatory response, evaluated with *Nos2* induction, NO production, and the secretion of pro-inflammatory cytokines. Moreover, both ASNP synergized macrophage activation by bacterial lipopolysaccharide (LPS), but a higher effect was observed for NM-203. In conclusion, we demonstrate that, compared to precipitated, pyrogenic ASNP exhibit enhanced interaction with serum proteins and cell membranes, cause a larger oxidative stress and elicited stronger pro-inflammatory effects in macrophages. Therefore, these two nanomaterials should not be considered biologically equivalent.



Diesel Exhaust Particulate derived from Euro3 and Euro4 engines modulates cardiac electrophysiology and enhances arrhythmias

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Background. Solid-state diesel exhaust particles (DEPs) represent the majority of particulate matter (PM) in the urban air pollution. Particles of this size intrude the alveoli, rapidly infiltrate cell membranes and are transported via the blood stream into organs. European Union (EU) has introduced the diesel particulate filter (DPF) from Euro4 engines and imposes severe restrictions in order to control particles emissions and associated gases. Despite DPF introduction has raised controversial viewpoints and the recent Volkswagen emissions scandal, is it imperative to ask ourselves if EU current legislation and efforts to reduce air pollution are currently enough for public health benefits.

Methods. Adult Wistar rats were instilled intra-tracheally with i) saline solution as vehicle (VE), ii) DEP from Euro3 (DEP3, without-DPF) and iii) Euro4 (DEP4, with-DPF) engines (2 mg/Kg). Four hours after instillation we measured electrophysiological parameters by multiple lead epicardial potential mapping (EPM) in the *in-vivo* heart.

Results. In DEP instilled animals, excitability was reduced, P and T wave durations decreased, while QRS complex and PQ interval durations increased significantly as well as refractoriness and conduction velocity along fibers. All these alterations were more exacerbated in DEP4 than in DEP3 instilled animals. Furthermore, arrhythmogenesis increased twofold in DEP4 group compared to control animals.

Conclusions. Despite Raman spectroscopy demonstrated the presence of microcrystalline Carbon in both DEP samples, instilled animals with DEP4 were more prone to arrhythmias compared to DEP3 suggesting that the reduced particular size (DPF-caused?) may play a pivotal role in the likelihood of arrhythmogenesis.

Nano- and microporous ceramic beads for efficient adsorption of Cr(VI) from water

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Chromium is a widespread water contaminant, largely arising from different industrial processes. Due to the high toxicity of hexavalent chromium [Cr(VI)] for population health, materials and processes enabling an efficient detection and removal of Cr(VI) from water is highly demanding. Ceramic materials are highly suitable as adsorbents due to their chemical and mechanical resistance. Here we present the synthesis of micron-sized yttria-stabilized zirconia (YSZ) porous beads for Cr(VI) removal and abatement.

Porous YSZ beads are obtained by ionotropic gelation, an environmental-friendly processing method which exploits the gelling properties of natural polysaccharides *e.g.* alginate. By gelling a ceramic-alginate slurry in the presence of multivalent cations, stable ceramics beads are obtained. Beads feature a tailorable morphology, specific surface area, open porosity up to 85% and pore with diameters from 0.3 up to 60 μm . The efficiency of the beads to adsorb Cr(VI) from aqueous solutions is tested by complementary techniques involving total x-ray fluorescence (T-XRF), x-ray powder diffraction (XRD), energy dispersive x-ray spectroscopy (EDS) and microRaman analysis. TXRF measurements show that microbeads adsorb within a short time from 0.01 up to 30 ppm Cr(VI) from solutions containing from 0.05 to 50 ppm Cr(VI). Chromium abatement varies between 10% and 90%, depending on the porosity of the microbeads and incubation time.

Moreover, a more efficient conversion of Cr(VI) in less toxic Cr(III) species and its simultaneous removal can be achieved either by tuning beads composition or by functionalizing them with specific receptors and nanocatalysts.



Hybrid liposomes decorated with glucocalix[4]arenes for targeted drug delivery

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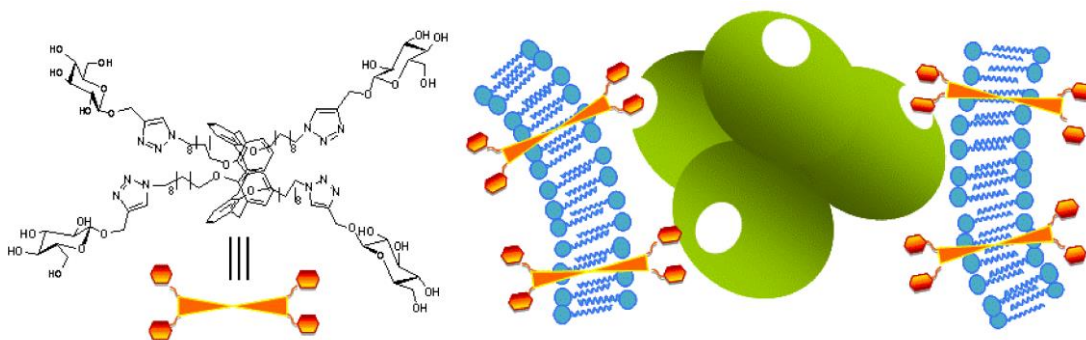
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The protein-carbohydrate recognition phenomena can conveniently be exploited for the targeted drug delivery, taking advantage from the numerous specific carbohydrate receptors present on the cell membrane¹⁾. The recognition process between these receptors and their saccharide substrates are frequently characterized by the occurrence of a multivalency effect, or glycoside cluster effect, that determines highly efficient and specific interactions¹⁾. For this reason, synthetic polyglycosylated systems are attracting great interest in nanomedicine as potential multivalent tools able to promote the targeting of specific cells and tissues. Calixarenes demonstrated in these years to be versatile scaffolds to build polyglycosylated derivatives²⁾ the glyco-calixarenes, that are efficient and selective ligands for carbohydrate recognition protein (lectins) of medical relevance. Recently we planned to combine properly designed glyco-calixarenes with liposomes³⁾ widely studied, proposed and used for drug delivery, to obtain new materials and systems with added advanced and innovative properties. Hybrid liposomes decorated with β -glucosylated calix[4]arenes (see figure) resulted to be able to interact with specific proteins and promote targeted delivery and cell uptake.



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Poster



Sol-gel synthesis and characterization of photocatalytic TiO₂

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The sol-gel process has been applied for the production of titanium dioxide in the form of nanocrystalline anatase ^[1], promising material for the photocatalytic degradation of environmental pollutants, being highly efficient, non-toxic and stable under irradiation ^[2]. In this work different water based sols of anatase, obtained in acidic or basic environment were synthesized and deposited on different building materials: artificial, as ceramic tiles and natural, as carbonatic stones. The aim was to give self-cleaning properties to the surfaces. The harmlessness of the coatings was assessed by capillary absorption tests and colorimetric measurements. In order to enhance the activity of titanium dioxide in the visible region, doping of anatase with rare earth ions was also tested ^[3]. The powders were analysed by Raman spectroscopy and X-ray diffraction (XRD): both techniques evidenced mainly TiO₂ anatase nanocrystals in the 5-10 nm range, with minor amounts of brookite. Methyl-orange (MeO) and methylene-blue (MB) were used as model contaminants to investigate the degradation activity under UV irradiation of the different sols in liquid phase. Colorimetric measurements were conducted to evaluate the photocatalytic activity of the coatings on the building materials in the degradation of methylene-blue, methyl-orange and rhodamine B (RB) stains under the irradiation of a sunlight lamp. The results showed good photodegradation activity and satisfactory compatibility between the coatings and the stone or ceramic surfaces.

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Hybrid inorganic-organic nano-composites for Wood and Paper protection

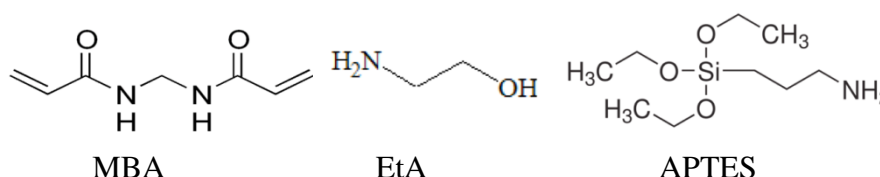
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The ligno-cellulosic materials (wood and paper) are conveniently used for a variety of human artifacts in virtue of their advantageous characteristics. However, their organic constitution is subjected to combustion, to long-term oxygen light and water degradation and to biological deterioration caused by various microorganisms such as bacteria, fungi and insects [1]. Here we present the characterization by ESI-MS, NMR, FTIR and μ -Raman spectroscopy of new polymers for the protection of artworks of interest for cultural heritage, in particular of lignocellulose materials. The polymers are polyamidoamines (PAA) functionalized with alcoholic or siloxanic groups (PAAOH or SiPAA) obtained from N,N-methylenebisacrylamide (MBA) by addition reaction with ethanolamine (EtA) or aminopropyltriethoxysilane (APTES), respectively. SiPAA (an hybrid inorganic-organic polymer) has been tested for wood, whereas PAAOH also for paper preservation [2].



The addition reactions (Michael-type reaction) have been followed by Raman spectroscopy, monitoring the decrease of the intensity of the C=C stretching mode of bisacrylamide.

Interpenetration of ligno-cellulosic materials by polymers has been monitored by microscopic (ESEM) and spectroscopic (Raman) techniques. The alkoxy silane groups of SiPAA gives hybrid organic-inorganic nano-networks through hydrolysis and condensation reactions (the sol-gel process).

In the case of paper, PAAOH was applied in aqueous solution or vehiculated by an Agar gel mainly for deacidification purposes. Preliminary results have shown that the polymer acts as an effective deacidification material without altering chromatic and mechanical characteristics of paper.

Financial support from Renner Italia SpA (Minerbio, BO) is gratefully acknowledged.

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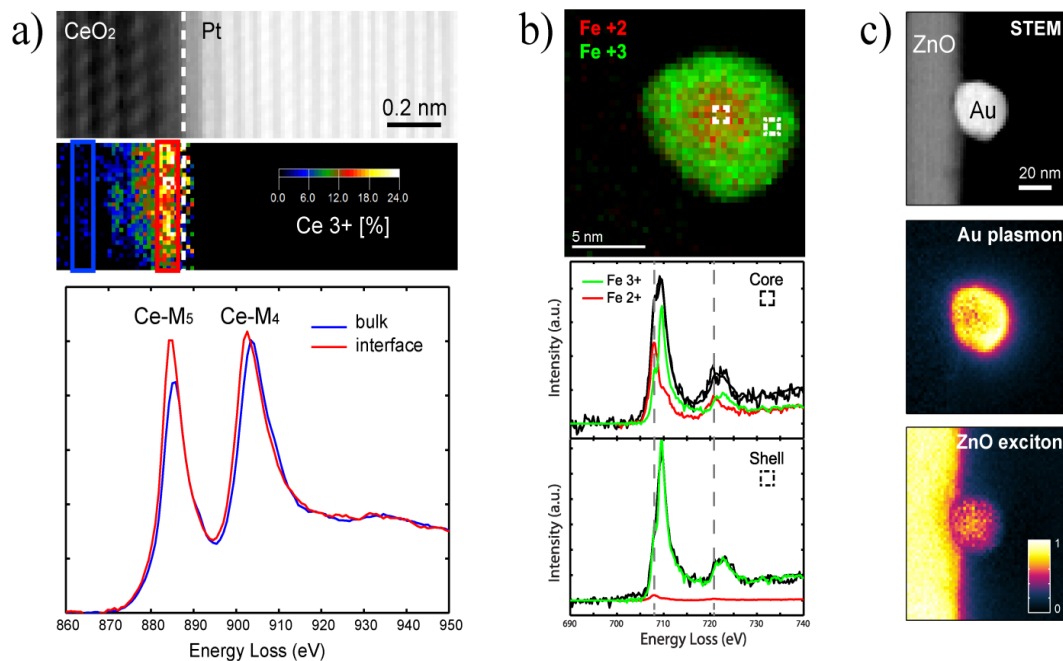
Spectroscopic and chemical characterization at sub-nanometer scale using STEM-EELS

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Nanoscale spectroscopy and its applications shed light on interdisciplinary research including engineering, physics, chemistry, biology, medicine and aerospace. Advanced materials require control of the structural properties at the sub-nanometer or atomic scale. This is mandatory in the case of interfaces for electronic devices, or in nanostructures, where the surface/interface has a fundamental role in view of their applications (*e.g.* nanoparticles for catalysis, functionalized nanoparticles, *etc.*). To fully characterize these systems the chemical information at high spatial resolution (even at atomic scale) has to be achieved. This is possible by using electron energy loss spectroscopy (EELS) in a scanning transmission microscope (STEM), taking advantage of last generation probe aberration correction and high resolution spectrometers. In this contribution we will show some examples of the use of this technique for resolving the oxidation state (valence) of atoms and their electronic configuration in different nanosystems. The first case is a CeO₂/Pt epitaxial heterostructure, in which EELS from the Ce-M ionization edge reveals a one atomic thick layer with a fraction of reduced Ce 3+ atoms (~15%) at the interface, and explained with interfacial charge transfer by DFT theory (see Fig.a). The other examples focuses on nanoparticles and functionalized nanostructures, in which for instance, EELS mapping of the oxidation state of the metal atoms can be used to resolve core/shell structures (Fig.b), or even to map the extension of the plasmons and excitons states in a coupled system as Au functionalized ZnO nanostructures (Fig.c).



Effects of acute exposure to cobalt oxide (Co₃O₄) nanoparticles on ventricular cardiomyocytes: electromechanical and cytotoxic characterization

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Background. We investigated the effects of acute exposure to Co₃O₄-NPs on electromechanical function, oxidative stress and genotoxicity in ventricular cardiomyocytes.

Methods. Cells were enzymatically isolated from rat left ventricles. Co₃O₄-NPs were suspended in sterilized water, and added at two different concentrations (5-50 μg/ml) to the myocyte suspension. Atomic Force Microscopy (AFM) was used to document the size of particles within the nano-scale range. Resting potential V_r , membrane capacitance C_m , duration of electrically driven action potentials (APD), diastolic sarcomere length L , fraction of shortening FS , maximal rate of shortening and re-lengthening ($\pm dL/dt_{max}$), Ca²⁺ transients, cytoplasmic presence of NPs, oxidative stress and DNA damage were measured in control and treated cells.

Results. AFM confirmed the nano-scale size of particles (<100 nm); Transmission Electron Microscopy revealed significant cytoplasmic presence of Co₃O₄-NPs, in intimate contact with myofibrils and within the mitochondria. At both tested NP concentrations, a higher incidence of spontaneous contractions was observed, associated with reduced APD, and with increase in V_r fluctuations. Cardiomyocytes exposed to NPs exhibited a reduction of FS , together with a significant decrease in the rate of shortening and re-lengthening ($\pm dL/dt$). Conversely, only 50 μg/ml of NPs exposure decreased both C_m and intracellular calcium clearing rate. ROS production and genotoxicity were also found increased in all treated cardiomyocytes.

Conclusions. Acute exposure of cardiomyocyte to Co₃O₄-NPs leads to particles internalization, worsening of electro-mechanical cellular function, ROS formation, and DNA damage. All these changes, together with shortening of APD, may result, at the tissue level, in a substrate more prone to arrhythmias.



Memristive devices prepared by atomic layer deposition

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Memristors are a class of new devices hypothesized by L. Chua in 1971, in which the resistance value depends on the past history of the device. In the memristor the resistance of the device increases when current flows in one direction, while the resistance decreases when the current flow is reversed. If the supply voltage is removed the memristor retains last resistance value, so it preserves “memory” of its history. A memristors network could theoretically work in a way very similar to neuron synapses, thus enabling the realization of novel kind of advanced devices.

Amongst the different ways to realize memristor the deposition of a thin layers of metal oxides is one of the most successful ones.

Atomic layer deposition (ALD) is a technique for thin film deposition that uses gas pulses, producing one atomic layer at a time. The thickness of the film in principle depends only on the number of deposition cycles, resulting in extremely high uniformity and thickness control.

Al₂O₃ and TiO₂ less than 100 nm thick were deposited on glass substrates on which Pt bars of micrometer size was deposited as both bottom and top contacts.

Good memristive behavior was found in two devices: Al₂O₃ devices, prepared in the form of a metal-insulator-metal stack of Pt/Al₂O₃/Ti and in a more standard Pt/TiO₂/Pt device.



Magnetic thin films research @ CNR - IMEM

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IMEM institute is active in research on magnetic thin films for different applications, such as data storage, sensors and actuators. Thin films and nanostructures of several magnetic materials have been designed and grown in the last years with the aim of facing specific issues of a given technological area: L1₀-FePt, Ni-Mn-Ga, Mn-Ga, Co-rich amorphous alloys.

Two remarkable examples will be presented, which demonstrate that understanding and controlling microstructure is crucial for tailoring magnetism: magnetic shape-memory Ni-Mn-Ga films and high anisotropy Mn-Ga films.

Magnetic shape-memory alloys, such as Ni₂MnGa, are multifunctional materials with a great potential for the fabrication of microdevices based on novel actuation and sensing mechanisms. In epitaxial Ni-Mn-Ga films we have obtained a giant magnetically induced reorientation of martensitic variants by microstructure engineering [1]. Such a large effect was never reported in thin films before.

The metastable tetragonal phase of Mn₃Ga shows a unique combination of low magnetization, high uniaxial anisotropy, high Curie temperature and high spin polarization, which make it very promising as ferromagnetic electrode in Magnetic RAMs. We have realized an in-depth structural and magnetic study on Mn_xGa_{1-x} films, to evidence the occurrence of an undesired orientation, which significantly affects the magnetic properties.

1. Adv. Mater. 27, 4760 (2015)



DNA Nanoparticles formed by Partially Fluorinated and by Hydrogenated Gemini Bispyridinium Surfactants for Nonviral Gene-Delivery

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Fluorinated cationic lipids have been proposed to obtain efficient gene expression in those biological fluids containing surfactants as pulmonary surfactants or bile salts, when genes have to be delivered to the respiratory or to the biliar epithelium. This is an essential requirement in the treatment of cystic fibrosis and cystic fibrosis-associated diseases. In fact, perfluorinated compounds show peculiar properties, between which the most interesting for biomedical applications is the chemical and biological inertness, due to their high hydrophobic and lipophobic character. These originate mainly from the structure of the fluorine atoms having a larger van der Waals radius and a lower polarizability than the hydrogen atoms. This is the reason why we have studied the formation and the transfection ability of DNA nanoparticles, formed by a homologous series of highly fluorinated 1,1'-di(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl) cationic *gemini* surfactants, differing for the length of the alkyl spacer bridging the two pyridinium polar heads in 1,1' position (PH2F8-*n* with *n* = 3, 4, 8, 12) in comparison with the behaviour of bispyridinium dihexadecyl cationic *gemini* surfactants, also differing for the spacer length (P16-*n* with *n* = 3, 4, 8, 12). Thermodynamic techniques, atomic force microscopy (AFM), electrophoresis mobility shift assay (EMSA) and transient transfection assays measurements were employed. Their performance in gene delivery is strictly related to their structure in solution as for their hydrogenated analogues. This finding confirms that the behaviour in solution is due to a conformation change of the molecule determined by stacking interactions between the pyridinium rings, appearing at an optimum spacer length.



Mid-IR supercontinuum generation in microstructured optical fibers

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Microstructured fibers are optical fibers whose cross-section is characterized by micrometer- or nanometer-scale features running throughout their entire length, which can be effectively designed to obtain peculiar optical properties, spanning from precisely-tailored dispersion to extremely low or high nonlinearity, from endlessly single-mode propagation to narrow band spectral filtering of transmitted light.

In this work, the key features of microstructured fibers are presented and the effects of the engineering of their cross-section are investigated. In particular, the attention will be focused on a the so-called Suspended-Core Fiber (SCF) design, whose cross-section, shown in Fig. 1, is characterized by a few nm-scale glass bridges which intersect to create a core with few μm width, separated by relatively large air-holes. Such design allows a strong enhancement of the guided mode field intensity and a good control of the dispersion properties, which can be exploited in combination to build highly nonlinear devices.

The results of numerical simulations, aiming to the optimization of the design of SCFs made with Chalcogenide glass to obtain broadband SuperContinuum Generation (SCG) in the mid-IR, will be shown. SCG is a collection of nonlinear processes which causes a huge spectral broadening of a short pulses, which is exploited to create ultra-bright broadband sources. For application in the mid-IR, Chalcogenide glasses such as As_2S_3 or As_2Se_3 are preferred to silica, thanks to their higher nonlinearity and extended transmission band. The influence of the cross-section parameters will be assessed and the possibility to generate a spectrum extending beyond 8 μm wavelength will be shown.

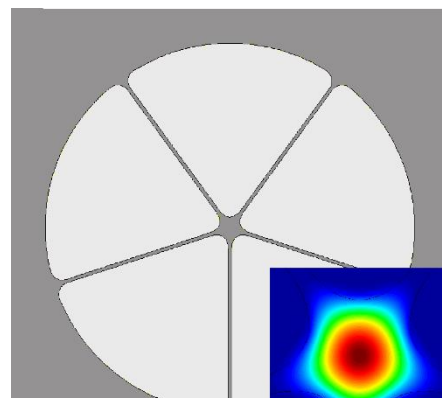


Fig. 1. Cross-section of a SCF. Inset: field distribution of the fundamental mode.

Electrochemical methods at the biology/electronics interface

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The term bioelectronics refers to the use of organic materials to create electronic devices with unique capabilities of interfacing with biological systems. This field of research represents one of the most dramatic technological developments of the past two decades. This contribution reports the results we have recently achieved in three main areas of bioelectronics.

(1) First we show the application of an electrochemical transistor based on organic electroactive materials as biosensor for the fine detection of different species of bioanalytes, such as drugs and drug-carriers.

(2) We report on the extensive use of organic devices for monitoring drug-induced cell death, as a complementary tool with respect to standard live/death fluorescence assays.

(3) Finally we illustrate an example at the very cutting edge of bioelectronics: interfacing electronic devices with a living system (namely the *Physarum Polycephalum* slime mould) used as an elementary memory unit for unconventional computing.



Influence of the interparticle dipolar interactions in the properties of magnetic nanoparticles for magnetic hyperthermia

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Magnetic nanoparticles are considered key nanomaterials for the development of future information storage, energy and biomedical and pharmaceutical applications. In the biomedicine, magnetic nanoparticles are suitable for both diagnostics and therapeutics. In the field of diagnostics, they have been proposed as contrast agents to enhance the magnetic resonance imaging signal, while in the field of therapeutics they can be used as magnetic vectors in drug delivery and/or heat mediators in hyperthermia treatment. In this last application, the apoptosis of cancer cells is produced by the local increase of the temperature thanks to the heating of the magnetic nanoparticles contained in the cells under an oscillating magnetic field. The physico-chemical mechanisms and effects that give rise to hyperthermia are under study. One of the most discussed questions is the role of the interparticle interactions induced by the different aggregation levels, which can be different in the laboratory conditions and into the cells.

Monodispersed Fe₃O₄ nanoparticles have been synthesized by two different synthesis routes, coprecipitation and thermal decomposition. Thanks to the different steric stabilizations, the nanoparticles present different aggregation levels. We observe different magnetic properties but also hyperthermia efficiency in these two types of nanomaterials. The structural and magnetic studies conclude that such differences in the properties depend on the aggregation configuration. Thanks to Lorentz microscopy studies we have visualized the different magnetic configurations stabilized by dipolar interactions, thus paving the way to the comprehension of the power loss mechanisms for different nanoparticle aggregates.



Subdiffraction localization of a nanostructured photosensitizer in bacterial cells

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Antibacterial treatments based on photosensitized production of reactive oxygen species is a promising approach to address local microbial infections. Given the small size of bacterial cells, identification of the sites of binding of the photosensitizing molecules is a difficult issue to address with conventional microscopy. We show that the excited state properties of the naturally occurring photosensitizer hypericin can be exploited to perform STED microscopy on bacteria incubated with the complex between hypericin and apomyoglobin, a self-assembled nanostructure which confers very good bioavailability to the photosensitizer. Hypericin fluorescence is mostly localized at the bacterial wall, and accumulates at the polar regions of the cell and at sites of cell wall growth. While these features are shared by Gram-negative and Gram-positive bacteria, only the latter are effectively photoinactivated by light exposure.

Cytotoxic effect of Camptothecin nanosponges in anaplastic thyroid cancer cells *in vitro* and in orthotopic xenograft tumors *in vivo*

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Anaplastic carcinoma of thyroid (ATC) is one of the most lethal human malignant cancers and to date there is no treatment that can successfully change its course. Nanotechnology allows the enhancement of drug availability and stability and the reduction of side effects. Camptothecin (CPT) is an inhibitor of DNA Topoisomerase-I with a wide spectrum of anticancer activities. The use of CPT has been hampered by a poor aqueous solubility and a high degradation rate. Previously, we reported that CPT encapsulated in β -cyclodextrin-nanosponges (CN-CPT) displays an enhanced inhibitory effect on the prostate tumor cells both *in vitro* and *in vivo*. Here, it has been evaluated whether β -cyclodextrin nanosponges carriers can display their antitumoral efficacy on two anaplastic thyroid carcinoma cell lines (Cal-62 and BTH-101) and on a thyroid tumor model *in vivo*. CN-CPT significantly inhibited cell viability, in the range of concentrations $2 \times 10^{-10} \text{M}$ - $6 \times 10^{-8} \text{M}$, showing a faster and enhanced effect compared to free CPT. The inhibition of clonogenic capacity and cell cycle progression validates previous obtained data. CN-CPT demonstrated its anti-metastatic potential by inhibiting tumor cell adhesion to endothelial cells (10^{-11}M - 10^{-8}M) and migration ($6 \times 10^{-8} \text{M}$ - $6 \times 10^{-9} \text{M}$). The effects on intracellular signalling by Western blot analysis revealed an inhibition of the Rho family activator β -PIX expression and of MAPK Erk1,2 phosphorylation. *In vivo* obtained data show that CN-CPT, in comparison with CPT, significantly inhibited growth and volume of orthotopic ATC xenografts in SCID/beige mice without apparent toxic effects. CN-CPT appear to be a promising tool also for the treatment of ATC.



Adsorption to nanoparticles shifts the transduction pathways activated by TLR ligands in innate immunity cells

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Engineered nanoparticles (NP) functionalized with TLR agonists are powerful enhancers of immune responses. However, we recently observed that the plain co-incubation with TiO₂ NP enhanced the pro-inflammatory effects mediated by LPS in macrophages (Bianchi et al., Toxicol. Res. 4, 385-398, 2015). We also observed synergy with TLR ligands for gold, polystyrene and SiO₂ NPs. Investigating the mechanism of the synergy, we demonstrated that TiO₂ NP, co-incubated with LPS, adsorbed the endotoxin. In terms of NF-κB-dependent pro-inflammatory gene expression and cytokine secretion by macrophages, the complex had much stronger effects than LPS or NPs alone. The phagocytosis inhibitor cytochalasin B did not prevent macrophage activation caused by either compound but abolished the synergistic effect, suggesting the targeting of the complex to endosomes. TLR4 inhibitors suppressed not only the effects of TiO₂ NP and LPS alone but also the synergy. While LPS effect was hampered by ERK1/2 inhibitors, the synergistic effect was sensitive to p38 but not to ERK1/2 inhibition. NP-LPS complex enhanced also the induction of *Ifnb1* suggesting the involvement not only of NF-κB but also of the TRIF-dependent pathway. Moreover, while the inhibition of the MyD88 adaptor completely abolished the NP-LPS synergy, the activation of macrophages by LPS was only partially suppressed under the same conditions. Thus, the adsorption to NPs not only change the effects of TLR ligands on immune cells but may also promote the activation of transduction pathways other than those triggered by the ligand alone.



Nanostructured TiO₂ memristive devices synthesized by PMCS technique for novel biological applications

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The bio-interaction between human beings and machines has been one of the most fascinating challenges in the last decade. Several complications in terms of biocompatibility, type of chemical signal and the scalability of the electrical devices are still present. Within this context, the memristor could be a possible candidate to create the missing link to allow this interaction, thanks to their particular electrical behavior similar to the neuronal response, their expectable biocompatibility and their nanoscale dimensions.

In this work, a vacuum-based deposition technique is proposed and exploited to synthesize TiO₂-based materials. Pulsed Microplasma Cluster Source (PMCS) is based on a supersonic beam seeded by clusters of metal oxide and it is used to grow nanocrystalline TiO₂ thin films at room temperature, controlling the oxide stoichiometry from metallic titanium to a significant oxygen excess. Morphological and chemical analyses of films produced with this technique are shown, together with relevant examples of metal-insulator-metal structures showing a pinched hysteresis loop in their current-voltage characteristics.

Some preliminary results on the biocompatibility of TiO₂ having different stoichiometries are presented, as well as the approaches to improve the quality of the adhesion/proliferation of several cell lines growing on the nanostructured metal oxides.

This work is developed in the framework of MaDEleNA project (Provincia Autonoma Trento, Grandi Progetti).



Nanowire platforms based on cubic silicon carbide for biomedical applications: cytocompatibility

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Nanowires (NWs) open promising near-future perspectives for the design and fabrication of biomedical nano-scale devices. In the last years the interests on nanomedicine has been growing, increasing the possibility of new treatments.

This study shows an innovative bottom-up approach to bio-mimicking that can be offered by cubic SiC-based NWs.

To evaluate the cytotoxic effect of SiC/SiO₂ and 3C-SiC NWs, the A549 and L929 cell lines were used. Cytotoxicity was analyzed by indirect and direct contact tests, the cell adhesion, and the cell proliferation.

SiC/SiO₂ core/shell NWs were synthesized by Chemical Vapor Deposition process, while the 3C-SiC NWs were obtained by wet chemical etching of the SiC/SiO₂ NWs.

For indirect cytotoxicity methods we followed the protocol in agreement with ISO 10993-5 guidelines for porous materials, and in order to test the cell viability we performed an MTT assay and a CellTiter-Glo assay. To evaluate the adhesion and proliferation of cells after 24 and 48h, the samples were investigated by fluorescence microscopy and SEM.

According to the observed viability, cells appeared to be more numerous on the flat samples than on the NWs after 24 h, likely indicating that cell adhesion was more difficult on the NWs. It was shown that integrin spacing is important to focal adhesion formation. Fluorescence data clearly show that both cell lines proliferate by 48 h, as confirmed also by SEM observation. This suggests that the NWs coated substrates have good biocompatibility and do not hinder cell growth.

These results indicate that the analyzed NWs samples are suitable biomaterials for implantable prosthetic devices and tissue regeneration.



A new hybrid nanosystem based on SiC/SiO₂ nanowires conjugated with porphyrins for X-ray-excited Photodynamic Therapy

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In the last decade an increasing attention has been focusing in the literature on the preparation of nanosystems for biomedical applications, such as drug delivery, bio-separation, immunoassays, and in particular for innovative approaches in cancer treatment, such as photodynamic therapy (PDT).

Here we report the preparation of a novel nanosystem obtained by functionalization of core-shell SiC/SiO₂ nanowires with porphyrins for application in photodynamic therapy.

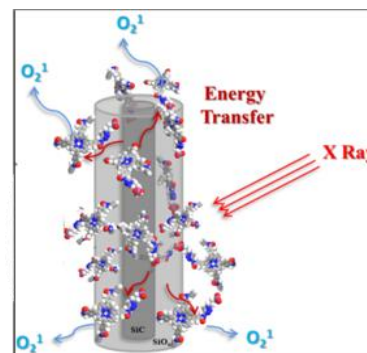
Cubic SiC was identified as a promising material in the biomedical field for its biocompatibility. Recently we evidenced that SiC/SiO₂ nanowires can easily penetrate the cell membrane and that they are cytocompatible.¹

Porphyrins are an important class of photosensitizers largely employed in PDT, absorbing light and producing singlet oxygen. We designed to conjugate porphyrins to the SiC/SiO₂ nanowires, obtaining a nanosystem able to promote X-ray-excited PDT for deep tumor treatment.²

Here we present an innovative conjugation strategy based on the formation of amide bonds.

Tetra(4-carboxyphenyl)porphyrin (H₂TCP) was linked to the nanowires surface through covalent amide bonds by reacting the porphyrin with the nanowires, previously functionalized with amino groups, under very mild conditions. Then, short hydrophilic PEG chains were synthesized and linked to the porphyrins to increase the dispersion of the nanosystem in a biological medium.

The hybrid nanosystem was characterized by fluorescence spectroscopy, that showed the successful porphyrin conjugation. In vitro studies on tumor cell lines are in progress and will be presented.



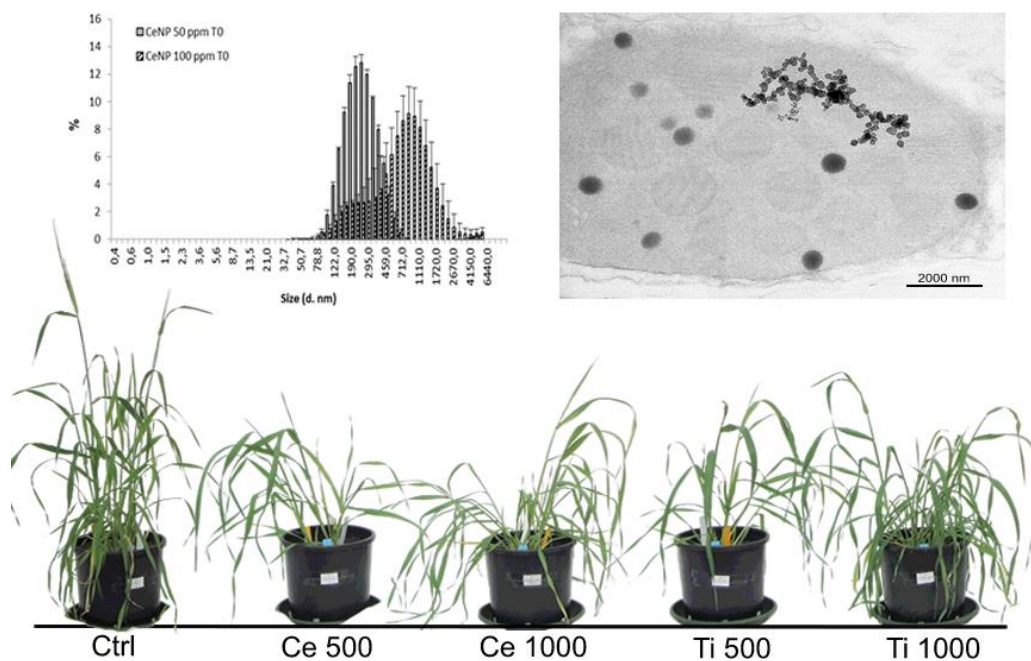
1) Cacchioli, A.; Ravanetti, F.; Alinovi, R.; Pinelli, S., Rossi, F.; Negri, M.; Bedogni, E.; Campanini, M.; Galetti, M.; Goldoni, M.; Lagonegro, P.; Alfieri, R.; Bigi, F.; and G. Salviati, *Nano Lett.*, **2014**, 14 (8), 4368–4375.

2) Rossi, F.; Bedogni, E.; Bigi, F., Rimoldi, T.; Cristofolini, L.; Pinelli, S.; Alinovi, R.; Negri, M.; Dhanabalan, S.C.; Attolini, G.; Fabbri, F. M. Goldoni, A. Mutti, G. Benecchi, C. Ghetti, S. Iannotta and G. Salviati *Scientific Reports* **2015**, 5:7606.

***nCeO₂* and *nTiO₂* influence the life cycle of *Hordeum vulgare* L.**

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The reactions of living organisms when exposed to metal nanoparticles (NPs) or NPs of different size are not well known. Very few studies on NPs-plant interactions have been published, so far. Thus, there is great concern regarding the potential NPs impact to food safety. The aims of our experiment were to evaluate the uptake and translocation of cerium and titanium oxide nanoparticles and to verify their effects, on the growth cycle of barley. Plants of barley were grown to physiological maturity in soil enriched with either cerium oxide nanoparticles (*nCeO₂*) or titanium oxide nanoparticles (*nTiO₂*) (0, 500 and 1000 mg kg⁻¹) and their combination. The growth cycle of *nCeO₂* and *nTiO₂* plants was about 10 days longer than the controls. In *nCeO₂* treated plants the number of tillers, leaf area and the number of spikes per plant were reduced respectively by 35.5%, 28.3% and 30% (p≤0.05). *nTiO₂* stimulated plant growth and compensated for the adverse effects of *nCeO₂*. Concentrations of Ce and Ti in aboveground plant fractions were minute. The fate of nanomaterials within the plant tissues was different. Crystalline *nTiO₂* aggregates were detected within the leaf tissues of barley.



Targeting bacterial cells with the fluorescent photosensitizer ZnMb

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“Theranostics” has been coined to describe the emerging area of research which focuses on the combination of diagnostic detection agents with therapeutic drug delivery carriers. Using a recombinant protein as a carrier of a photosensitizer could be a novel strategy for photodynamic therapy because of their ability to target and treat specific sites while also allowing noninvasive monitoring of particle localization. In this work we use myoglobin reconstituted with Zn-protoporphyrin IX as theranostic agent and we test its availability on *S. aureus* and *E. coli* colonies, as representative of Gram-positive and Gram-negative bacteria. This complex maintains a good high quantum yield of fluorescence emission and shows a very efficient production of singlet oxygen. Fluorescence microscopy shows a bright fluorescence emission appears from bacterial walls both for *E. coli* and *S. aureus*. It thus appears that ZnMb reaches the cell surface for both gram-positive and gram-negative bacteria. The lack of activity against gram-negative strains is most likely due to their second external membrane.



New mannosylcalixarenes as ligands for the inhibition of HIV/DC-SIGN interaction

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Carbohydrate-protein interaction events are at the basis of cell communication and other physiological phenomena but they also promote pathological infections, toxin adhesion to cells and spread of tumors. Among pathogens, the human immunodeficiency virus is a big challenge of current times and huge efforts have been made to develop vaccines and new therapies¹. One of the main pathway of infection of the virus exploits, through a “Trojan Horse” strategy, dendritic cells (DCs) that efficiently transfer virions to T-cells, where replication takes place². Among pattern recognition receptors expressed on DCs surface, DC-SIGN (Dendritic Cell-Specific ICAM-3 Grabbing Nonintegrin), a C-type lectin, is strongly involved in the process being able to interact with the high-mannose glycans of envelope glycoprotein gp120 present on the virus capsule and then exploited by the pathogen to attack lymphocytes.

Therefore, different research groups are focusing their work on the development of glycomimetic compounds that could interfere with gp120/DC-SIGN interaction. Because of the tetrameric form of the receptor and its organization on cell surface into clusters a multivalent approach seems to be a valuable strategy to improve ligands efficiency and selectivity. In this context, we designed and synthesized a small series of polymannosylated calixarenes (Figure 1). Calixarenes are very convenient scaffold for building multivalent ligands because of the possibility of tuning valency and geometry of the ligating units in space³. Preliminary experiments by Surface Plasmon Resonance evidenced the ability of our compounds to bind to DC-SIGN and prevent its interaction with a polymannosylated BSA used as model of the viral gp120 glycoprotein.

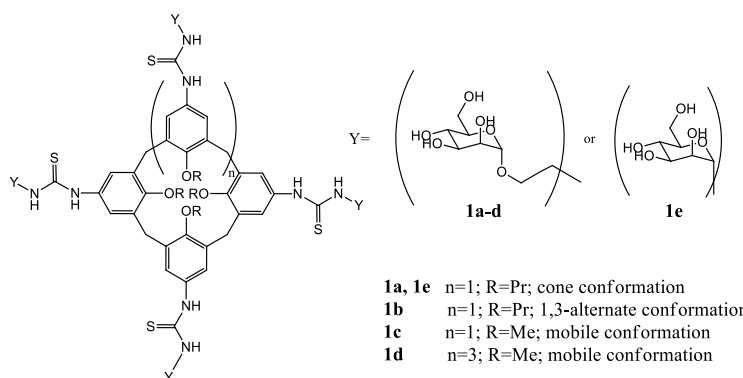


Figure 1. Molecules synthesized in this work.

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CdS quantum dots and CdSO₄: different oxidative stress responses and uptake in *A. thaliana* w.t.

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Plants of *A. thaliana* (*L. erecta*) w.t. were tested *in vitro* at three growth stages (15, 30, 45 days) with three different concentrations of either CdS QDs or CdSO₄. The contaminants were supplemented in agarised MS medium respectively as water-soluble nanoparticles or as salts at concentrations corresponding to 0, 1/3 MIC, 2/3 MIC (MIC being the minimum concentration for growth inhibition). Plants were analyzed for the content of Cd (flame-AAS), chlorophylls, carotenoids and total phenolics in addition to the leaf respiration rate (TTC assay) and the antioxidant activity (ABTS and DPPH assay). ESEM/EDX was used to detect morphological changes at the level of organs and tissues in leaves and roots; microanalysis was performed to verify Cd uptake in roots and plants estimating root-shoot translocation and to identify possible sinks for Cd storage. These parameters were used to establish a correlation between the oxidative stress response of the plants to different contaminants (Cd-containing nanoparticles or Cd bulk material), at different concentrations and varying the time of growth. Taking into account the natural senescence process of *A. thaliana* (particularly evident after 45 days), we evidenced substantial differences in the response of the plants to the two types of contaminants. Cd was detected in roots and leaves, especially in trichomes, of plants treated with high CdS QDs. Comparing CdSO₄ and CdS QDs toxic effects significant differences emerged in relation to the type and time of treatment. CdSO₄ was more toxic and caused higher levels of oxidative stress than CdS QDs.



Synthesis of one dimensional and two dimensional nanostructures for nanomedical applications

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One dimensional structures at the nanoscale show interesting properties that are studied for electronic devices, optics and nanoelectromechanical systems, but an increasing interest is arising for their applications in the biomedical field.

Our perspective is to synthesize them via bottom-up vapour phase epitaxial techniques and this allows us to tailor the desired morphological and structural properties and to design nanosystems for different applications.

We were able to obtain silicon nanowires, silicon carbide nanowires, silicon oxide nanowires and, using a facile self-assembly process, core-shell silicon carbide / silicon oxide nanowires.

We followed the results of the synthesis characterizing the structure and morphology of the nanowires using scanning electron microscopy and transmission electron microscopy. We obtained interesting optical properties using carbon doping on silicon oxide nanowires and exploiting the quantum well structure of the core-shell nanowires.

This allowed us to adapt the synthesis parameters in order to affect the morphology and to find the optimal conditions with the purpose of increasing the biocompatibility and biomimetics in the biological systems.

The synthesis of two dimensional structures (thin films) was optimized in order to find the best parameters to achieve highly crystalline silicon carbide biocompatible films with optimal chemical resistance to harsh environments. We were able to dope the films with nitrogen (n-type doping) or aluminium (p-type doping) in order to replicate the traditional electronic devices on a biocompatible material.

Applications in different branches of nanomedicine for these structures are presented: drug delivery, prosthetics and oncological treatments are some of the most promising.



Enhanced Luminescence of Polychlorotriphenylmethyl (PTM) and Trichlorophenylmethyl (TTM) Radicals

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Open-shell organic radicals are multifunctional materials with opto-electronic properties that can be used in a wide field of technological applications. However, the high reactivity of radicals typically prevents their commercial exploitation. But among them, polychlorotriphenylmethyl (PTM) and trichlorotriphenylmethyl (TTM) radicals, with a propeller-like conformation, show high stability and persistence. Their peculiar optical properties and the possibility to display strong nonlinear optical responses make them interesting candidate materials for opto-electronic applications.

In this work, we present different strategies to improve the luminescence and photo-stability of PTM and TTM radicals. Not only the effects induced by different solvents and by temperature are investigated, but also we describe new interesting nanosystems, namely purely organic nanoparticles of these radical species. In particular, we investigate the effects of co-precipitating the nanoparticles of radical species together with a second “diluting” optically-neutral organic species. The obtained composite nanoparticles are highly luminescent and an interesting trend is observed: when increasing the radical amount, a second, red-shifted emission band is obtained, characterized by long lifetime, while the luminescence intensity decreases. We ascribe this phenomenon to the formation of multiplet excimers in the nanoparticles with high radical amount.

A complete morphologic characterization is also obtained for the nanoparticles via Transmission Electron Microscopy, Dynamic Light Scattering and Zeta potential analysis.



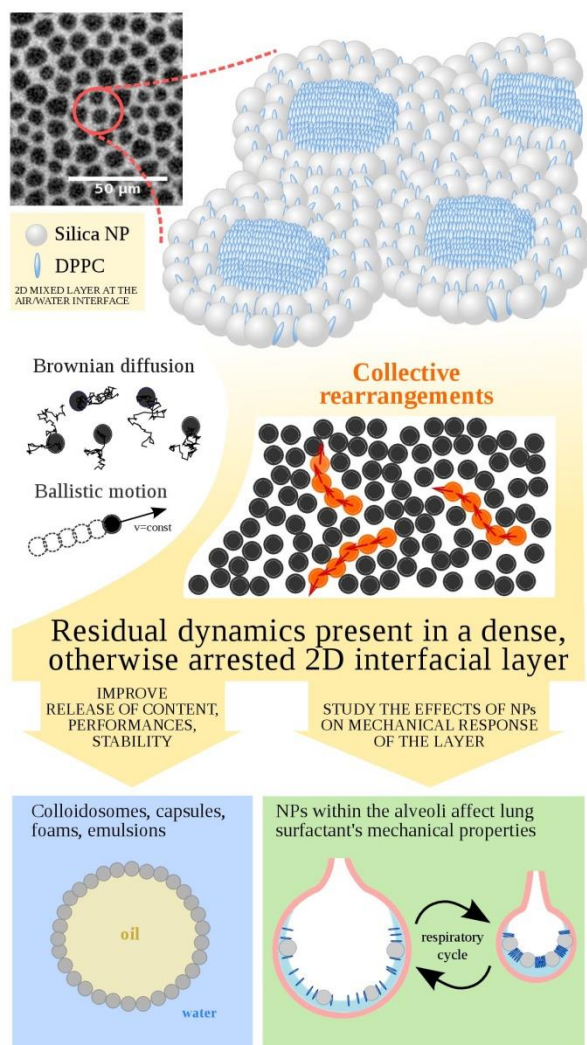
Dynamical heterogeneities and arrest in 2D networks of nanoparticles

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We investigate the interfacial dynamics of 2D self-organized mixed layer made of silica nanoparticles interacting with phospholipid (DPPC) monolayers at the air/water interface. These systems have biological relevance, allowing investigation of toxicological effects of nanoparticles on model membranes and lung surfactants. In perspective, they also pave the path towards bio-inspired technological solutions, exploiting the self-organization of DPPC to produce a non-trivial 2D structuration of nanoparticles.



The characterization of interfacial dynamics yields information on the effects of NPs on the mechanical properties, important to improve performances of systems such as colloidosomes, foams, creams. For this, we combine micro-tracking in real-space with measurement in momentum-space via x-ray photon-correlation spectroscopy and Digital Fourier Microscopy. Using these complementary techniques, we extend the spatial range of investigation beyond the limits of each one.

In systems with hydrophilic nanoparticles we find a dynamical transition from Brownian diffusion to an arrested state driven by compression, characterized by intermittent rearrangements, compatible with a repulsive glass phase. Hydrophobic nanoparticles, on the contrary, produce an elastic gel network whose dynamics is compatible with the random relaxation of dipolar stresses.

The rearrangement and relaxation of the monolayer structure results dramatically hindered by the presence of NPs, which is relevant to explain some the mechanical features observed for the dynamic surface pressure response of these systems and which can be relevant for the respiratory physiology and for future drug-delivery composite systems.

Mitochondrial effects of CdS quantum dots in a human hepatoma cell line

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Cadmium toxicity in humans has been documented for 50 years and, as a result, cadmium has been classified by IARC as category 1 carcinogen. The rapid development of nanotechnology and the spread of cadmium-containing nanomaterials promoted deeper investigation on human and environmental health risks. Cadmium sulfide quantum dots (CdS QDs) are widely used in the electric and electronic industries to produce semiconductor structures, solar energy and optoelectronic devices. It has been shown that CdS as nanoscale material has different physical and chemical properties than its "bulk" counterpart.

The aim of the research is to evaluate cytotoxic and genotoxic potential of the CdS QDs in human cells and to understand the mechanism involved. A human hepatoma cell line (HepG2) was used as a model to determine the toxic effects of the exposure to CdS QDs.

Uptake of CdS QDs was determined by flow cytometry and MTS assay was used to assess the viability of the human tumor cells exposed towards increasing concentrations of CdS QDs (1.5÷100 µg/ml). For the molecular characterization of the mechanism involved in nanomaterials toxicity, gene expression analysis was performed by means of Real time-PCR in HepG2 cells treated with two different concentrations to simulate "low toxic" (3 µg/ml) and "highly toxic" conditions (14 µg/ml). DNA damage was measured using Comet assay showing lack of genotoxicity in tested conditions. Furthermore ROS generation was assessed using the fluorescent probe 2',7'-dichlorodihydrofluorescein diacetate.

Overall, the study demonstrated that CdS QDs may induce mitochondrial depolarization through the disruption of key cellular processes.



High-throughput genomic and transcriptomic analysis of CdS QDs response in *Saccharomyces cerevisiae*

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Nanotechnology is a rapidly growing industry, with a market value expected to reach US\$ 49 billion by 2017 (Nanotechnology Market Outlook 2017, RNCOS, May 2013).

Engineered nanomaterials (ENMs) are structures on the range of 1-100 nm, characterized by peculiar properties due to their small size and surface reactivity that make them suitable for several industrial applications. Because of their wide diffusion and of the lack of information about mechanisms of biological uptake and interaction with cells, it's crucial to assess the risks linked to their spread and behaviour in the environment. The aim of this work was to analyse the response of *Saccharomyces cerevisiae* model system to CdS QDs, exploiting high-throughput genomic and transcriptomic approaches: the former consisted in screening a collection of 6000 haploid strains, with a deletion in genes that are not essential for yeast's survival; the latter consisted in a whole-transcriptome analysis of expression levels through Affymetrix GeneChip Microarray platform.

The data were analysed through different bioinformatics tools to identify the genes and main pathways of response to CdS QDs. In particular, mitochondrial organization and mitosis seemed to be the main biological processes impaired by CdS QDs toxicity.

Results obtained could therefore provide information on biological mechanisms and key role genes involved in nanomaterials response in yeast cells and, more in general, in higher eukaryotes and humans.



Proteomic characterization of CdS QD-binding proteins in *Saccharomyces cerevisiae*

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Nanotechnology is an emerging branch of applied science and technology for designing tools and devices of size 1-100 nm. Engineered nanomaterials (ENMs) have been widely used in several fields from medical to electronics and are characterized by unique physico-chemical properties as compared to their bulk materials. The increasing interest for nanotechnology-based consumer products and their biomedical applications has led to great excitement about their potential benefits, but there is a need to understand potential human health and environment risks from ENM exposure. When ENMs come into contact with a biological fluids, they interacting with several biomolecules, especially with proteins that bind their surface forming a biological coating around the ENMs known as the “protein corona”. These protein coronas can affect intracellular uptake and the outcome of the biological response to the ENMs.

In this work, we studied the effects of interactions between cadmium sulfide quantum dots (CdS QDs) and *S. cerevisiae* proteins. Identification of QD-binding proteins was performed with mass spectrometry (LTQ ORBITRAP XL) and different molecular approaches are used to characterize their interactions. Translational elongation factors, proteins involved in energy metabolism and molecular chaperones are found strongly associated to CdS QDs. A thorough understanding of protein corona composition may be needed to modulate the ENM toxicity or be used for specific applications of ENMs.



AmpRGD-Functionalized Liposomes Loaded with a VEGFR Inhibitor for a Targeted and Combined Antiangiogenesis Activity

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In recent past years an increasing interest has been observed in the role that cell surface receptors as integrins play in tumor genesis and progression. Some integrin subfamilies ($\alpha_v\beta_3$, $\alpha_v\beta_5$ and $\alpha_5\beta_1$) are involved, even by close cooperation with other cell receptors (e.g. vascular endothelial growth factor receptors, VEGFRs) in tumor angiogenesis, which has a crucial role in tumor development and dissemination.¹ The overexpression of several integrins in tumor related endothelial cells (ECs) and in various types of solid tumors makes them eligible targets for anti-angiogenesis intervention. Moreover, recent studies demonstrated that the $\alpha_v\beta_3$ integrin receptor is physically and functionally correlated with VEGFR2 within ECs,² suggesting that a dual specific agents capable of inhibiting them would have a great anti-angiogenesis potential. Our group has introduced a new class of integrin ligands, cAmpRGD, containing the Arg-Gly-Asp (RGD) sequence and 4-aminoproline scaffolds, able to efficiently and selectively bind to $\alpha_v\beta_3$,³ and it has used these ligands for the construction of doxorubicine loaded AmpRGD liposomal nanoparticles that rapidly deliver the chemotherapeutic agent to $\alpha_v\beta_3$ -expressing tumor cells.⁴

On these bases, our goal is the construction of novel vascular targeting liposomes obtained by self-assembly of AmpRGD-based lipopeptides and natural phospholipids, loaded with a VEGFR2 inhibitor. The AmpRGD recognition sites exposed on the external surface of the liposome are intended to permit selective delivery of the anti-VEGFR2 unit towards the over-expressing $\alpha_v\beta_3$ integrin tumor cells, and at the same time to exercise their antiangiogenesis function together with the VEGFR2 inhibitor released *in situ*.

The preparation of AmpRGD-functionalized liposomes, their physicochemical characterization and the VEGFR-inhibitor loading procedures will be reported, together with some preliminary *in vitro* biological results.

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Synthesis of one dimensional and two dimensional nanostructures for nanomedical applications

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One dimensional structures at the nanoscale show interesting properties that are studied for electronic devices, optics and nanoelectromechanical systems, but an increasing interest is arising for their applications in the biomedical field. Our perspective is to synthesize them via bottom-up vapour phase epitaxial techniques and this allows us to tailor the desired morphological and structural properties and to design nanosystems for different applications. We were able to obtain silicon nanowires, silicon carbide nanowires, silicon oxide nanowires and, using a facile self-assembly process, core-shell silicon carbide / silicon oxide nanowires. We followed the results of the synthesis characterizing the structure and morphology of the nanowires using scanning electron microscopy and transmission electron microscopy. We obtained interesting optical properties using carbon doping on silicon oxide nanowires and exploiting the quantum well structure of the core-shell nanowires. This allowed us to adapt the synthesis parameters in order to affect the morphology and to find the optimal conditions with the purpose of increasing the biocompatibility and biomimetics in the biological systems. The synthesis of two dimensional structures (thin films) was optimized in order to find the best parameters to achieve highly crystalline silicon carbide biocompatible films with optimal chemical resistance to harsh environments. We were able to dope the films with nitrogen (n-type doping) or aluminium (p-type doping) in order to replicate the traditional electronic devices on a biocompatible material. Applications in different branches of nanomedicine for these structures are presented: drug delivery, prosthetics and oncological treatments are some of the most promising.



Coenzyme Q₁₀ Nanosuspensions for Nebulisation

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Coenzyme Q₁₀ (CoQ₁₀) is an endogenous antioxidant used for the treatment of cardiovascular and neurodegenerative diseases. In the last few years it was investigated in several studies for its possible use in the adjuvant therapy for lung cancer.

The aim of this work was to prepare CoQ₁₀/lecithin nanosuspensions for nebulisation in view of the treatment of lung cancer patients.

The approach used was to prepare a CoQ₁₀ nanosuspension through high pressure homogenization with highly biocompatible excipients. In detail it was prepared a suspension of CoQ₁₀:lecithin:mannitol (0.5:0.5:5) dispersed at the concentration of 6% w/v in water:ethanol (70:30) and then homogenized at 1500 bar with 20 subsequent passages.

The solid lipid nanoparticles (Figure 1) obtained, as evidenced through WAXS, presented a particle size of 41.5 nm and z-potential of -24.6 mV.

The nanosuspension was directly nebulised after the ethanol evaporation through rotavapor (particle size 49.1 nm). For the ethanol-free SL nanosuspension the CoQ₁₀ emitted dose was 24.3 ± 0.02 % when nebulised with a LC Sprint ampoule assembled with PARI BOY compressor.

In order to provide a long-term stable formulation, the nanosuspension was freeze-dried and a powder suitable for extemporaneous dispersion in saline before nebulisation was obtained.

However, the freeze-drying process did not preserve the nanosize dimension of the homogenized suspension (Dv50: 2.8 μ m) and the respiratory performance, in terms of emitted dose, of the freeze-dried powder, re-dispersed in saline was 12.9 ± 0.01 %.

Both preparations showed a respirable sized droplets when nebulised in front of a laser beam for laser diffraction size distribution analysis (Dv50: 4.7 μ m), evidencing that maintaining the formulation particle size distribution in the sub-micron range is pivotal to an efficient deposition in the lung.

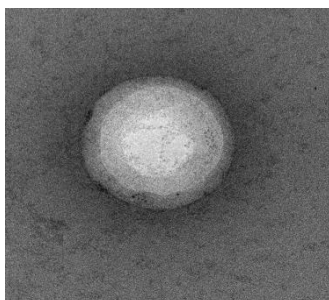


Figure 1. TEM of the Solid Lipid Nanoparticles

“Stainless” Gold Nanorods as robust and reusable SERS-active substratesEnzo Rotunno^{1,#}, Irene Vassalini², Laura Lazzarini¹, and Ivano Alessandri²¹IMEM-CNR, Parma²INSTM and Chemistry for Technologies Laboratory, Mechanical and Industrial Department, University of Brescia

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Gold nanorods (Au NRs) have been intensively investigated for their applications in material science. Most of them rely on the exploitation of localized surface plasmon resonance (LSPR), which gives rise to a strong enhancement of the local electromagnetic field near the nanorod surface. The position of the LSPR peaks can be finely tuned changing the Au NR aspect ratio. Therefore Au NRs are well suited for surface-enhanced Raman spectroscopy (SERS).

The opportunity to optimize LSPR is challenging SERS to extend its range of applications to the detection of analytes under real working conditions.

In this regard, Au NRs must keep their size and shape in order to maintain their optical properties unaltered during the experiment.

One of the main limitations to the application of Au NRs as SERS probes for in situ monitoring of chemical processes is their instability in oxidative environments. Oxidation induces progressive anisotropic shortening of the NRs which are eventually dissolved.

Here we discuss the results of SERS experiments in oxidizing environment for different types of Au NRs.¹ The key factors influencing their resistance to oxidation were systematically investigated allowing the synthesis of NR stable under harsh environments for several weeks. The most stable Au NRs were also demonstrated to be highly efficient SERS substrates in a series of Raman experiments simulating the oxidation of organic pollutants in water.

These characteristics make these “stainless” Au NRs attractive tools for ultrasensitive diagnostic under real working conditions.

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A new Ge doped Sb₂Te₃ polymorph

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Sb₂Te₃ is a small band gap (0.28 eV) semiconductor of interest as a topological insulator, a thermoelectric material and a phase change compound for application in Phase Change Memories (PCM).

In particular, when obtained as nanowires (NWs), Sb₂Te₃ can exhibit a lower melting point and yield lower reset currents in comparison with thin film-based, conventional PCM cells. Moreover, nanostructures allow for a defect-free scaling down in the fabrication of high performing PCM devices.

In this work we present a study on the self assembled MOCVD grown Ge-doped Sb₂Te₃ NWs, obtained on SiO₂ substrates through the VLS mechanism assisted by Au catalyst nanoparticles.

The synthesized NWs were found to exhibit an unexpected crystal structure. The new polymorph was characterized by combining electron diffraction and STEM-HAADF imaging.

The thermodynamic stable Rhombohedral R-3m (S.G. 166) phase of Sb₂Te₃, having lattice parameters $a = 0.423$ nm and $c = 3.046$ nm, consists in 15 atomic planes stacked along the c -axis. The new polymorph was found to crystallize in the trigonal system, space group P-3m (S.G. 164), with lattice parameters $a = 0.426$ nm and $c = 1.060$ nm and only 5 atomic planes stacked along the c -axis¹.

Ab initio density functional theory calculations were employed to investigate the existence of the new polymorph and its stabilization in form of NW. The theoretical results, combined with the structural information, can explain the appearance of the TLS.

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Gold nanoparticles decorated with mannosylcalixarenes for cell targeting

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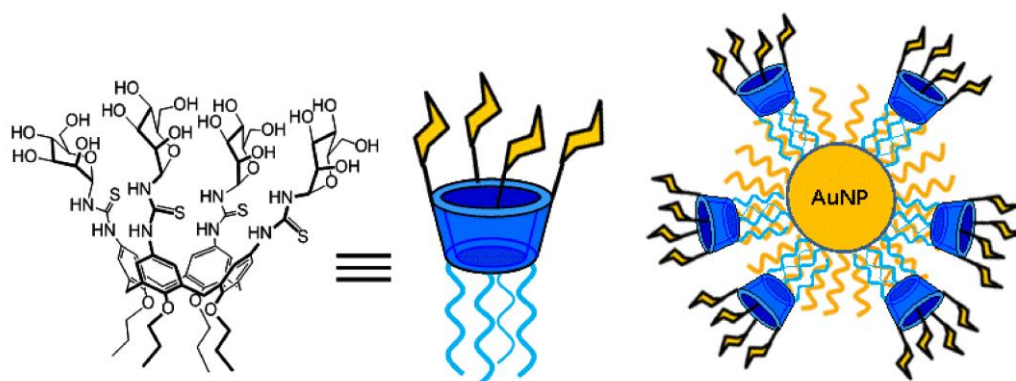
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The protein-carbohydrate recognition phenomena can conveniently be exploited for the targeted drug delivery, taking advantage from the numerous specific carbohydrate receptors present on the cell membrane.¹ The recognition process between these receptors and their saccharide substrates are frequently characterized by the occurrence of a multivalency effect, or glycoside cluster effect, that determines highly efficient and specific interactions.¹ For this reason, synthetic polyglycosylated systems are attracting great interest in nanomedicine as potential multivalent tools able to promote the targeting of specific cells and tissues. Calixarenes demonstrated in these years to be versatile scaffolds to build polyglycosylated derivatives,² the glyco-calixarenes, that are efficient and selective ligands for carbohydrate recognition protein (lectins) of medical relevance.

Recently we planned to combine properly designed glyco-calixarenes with gold nanoparticles,³ to obtain a new materials and system with added advanced and innovative properties. Hybrid gold nanoparticles decorated with α -mannosylated calixarenes (see figure) resulted to be able to interact with specific proteins and promote targeted delivery and cell uptake.



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Study and design of a photocatalytic reactor based on nanocrystalline TiO₂ for water purification

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Titanium dioxide is one of the most popular n-type semiconductor, largely used because of its remarkable characteristics, such as biocompatibility, stability under a wide range of conditions and low costs. Moreover, exposition to UV light makes TiO₂ photocatalytically active ^[1]; since 1980s powdered TiO₂ has been studied to purify wastewater and polluted air, exploiting its strong photoinduced oxidation power ^[2]. In this work it is therefore described the planning of a photoreactor for the treatment of waste and process waters. In the design stage of a photocatalytic reactor it is fundamental to maximize the surface area of the catalyst exposed to UV light and, at the same time, ensure the contact time required for oxidation reactions. These two requirements are often conflicting and an advanced design phase is therefore required. In this context Computational Fluid Dynamics (CFD) simulation is a fundamental support, since it allows to predict the efficiency of the process for different plant geometry according to the real operating conditions. Different nanocrystalline TiO₂ sols were synthesized and deposited onto the optimized supports; an exsiccation step was used to produce photoactive coatings. A proper set of UV lamps was set to have the most efficient irradiation. The activity of the photoreactor was tested following the degradation of dyes, used as model molecules.

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Nanoemulsions: adjuvants for nasal vaccines

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Vaccine technology has overstepped the use of live or attenuated pathogens and is proposing the use of highly purified antigens or even nucleic acids coding for such antigens. This approach has evidenced the need of additives able to amplify, modulate and direct the immune response to such antigens. Emulsions have emerged as the most successful adjuvants both in human and veterinary vaccines.

Our research group has recently developed a nanoemulsion formulation obtained by low energy emulsification of vitamin E, a known immunostimulatory agent, and aqueous phases rich in mucoadhesive polysaccharide in presence of non-ionic tensioactives. The formulation, conceived as an adjuvant for nasal vaccination, present droplets size that can be tailored based on the surfactant-to-oil ratio.

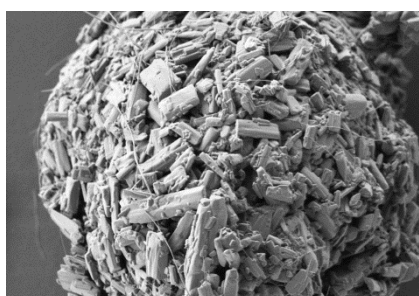


Fig. 1. SEM images of the surface of a mannitol crystal agglomerate carrier showing nanofilaments after the surface layering of a nanoemulsion

The adjuvant proved to retain the immunostimulatory properties of *Mycobacterium hyopneumoniae* when tested with the ELISpot technique, in view of a use to prevent respiratory infections in piglets.

In order to provide a vaccine suitable with long storage stability, no need of refrigeration and further capability to be retained on nasal mucosal tissue, the nanoemulsions were transformed in a

powder formulation by surface layering and drying over carriers with different water solubilities, i.e. mannitol, lactose and calcium carbonate (Figure 1). Nanoemulsions could be re-obtained by the dispersion of such powder formulations in aqueous media, opening the possibility to load the adjuvant and the antigen on the surface of dry powders suitable for nasal insufflation.

3D printing of nanocomposites: optimisation of the stereolithography process

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The general purpose of rapid prototyping (RP) is producing complex freeform solid objects directly from a computer model of an object without part-specific machinery. This approach allows reduction of product development time by shortening the period between design and testing. Thus, RP techniques are very convenient for building microcomponents, e.g. microreactors. Also known as photo-fabrication, the stereolithography (SL) may open new markets for exploiting nanostructured materials' characteristics and properties for unique rapidly manufactured devices. In this work, silica nanoparticles and acrylic resin were used for the development of silica-acrylic nanocomposites.

Silica is a very promising material for micro-devices produced by rapid prototyping techniques due to its high transparency, thermal and chemical resistance.

Controlled amounts of silica nanoparticles were successfully dispersed in acrylic-based resins and complex three-dimensional (3D) parts were fabricated. The effect of the nanosized filler and post-curing time were evaluated by means of mechanical and chemical-physical testing.

The Young modulus and tensile strength of the samples were determined in tension tests.

Curing (UV initiated) characteristics before and after post-curing were studied using FT-IR spectroscopy.

It was found that uncured and partially cured samples caused distortion and mechanical properties decreasing.

The results of the study confirm that the presence of nanoparticles favorably affects the reaction kinetics and final mechanical properties. The strength increased from 50 MPa for unfilled resin to 80 MPa for the nanocomposites with 50 wt% of silica nanofillers content. The building accuracy increased significantly with increasing content of silica nanofillers.



Controlled Oriented Aggregation for the Synthesis of Novel Iron Oxides Nanostructures

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Growth by particle attachment is an already well demonstrated growth pathway for nanocrystals in general, but many fundamental aspects, still unknown, make it a relatively open topic¹. Iron oxides nanoparticles (FeOX NPs) are one of the most important and studied nanomaterials for biomedical applications, especially in the field of theranostic². A lot of possible applications of these NPs have been demonstrated, like drug delivery, magnetic resonance imaging and magnetic hyperthermia for cancer treatment, that consists on the capability of FeOX NPs to heat in the presence of an alternate magnetic field³.

Calixarenes are organic aromatic macrocycles that owe their name to the characteristic three-dimensional ‘cup’ shape, which were already found capable to functionalize iron oxides surfaces⁴. In this work we demonstrate how p-tertbutyl calix[8]arene can induce oriented aggregation of FeOX NPs to obtain homogeneous monocrystalline 45 nm magnetite nano-octahedra. The high control gained with this process allows the possibility to stop the reaction before the aggregation process is completed, when crystals are at a multi-core state, with very interesting magnetic and hyperthermic properties. All the structures were then functionalized and made water-dispersed and biocompatible.

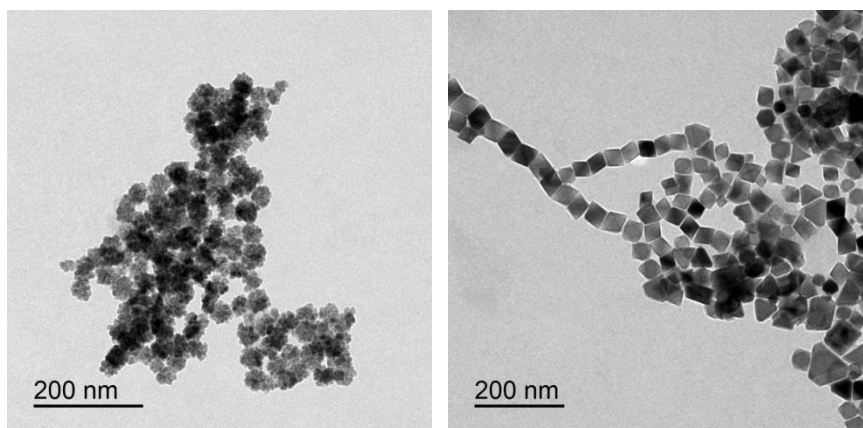


Figure 1. TEM micrographs of the a) Multi-core and b) Octahedric FeOX nanostructures

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Bifunctional metal ion/guanidinium catalysis in a calix[4]arene-based artificial phosphodiesterase

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An important goal of supramolecular chemistry is the design of artificial catalysts able to mimic the activity of enzymes. Recent studies showed that effective artificial phosphodiesterases can be successfully obtained by functionalizing the upper rim of *cone*-calix[4]arenes with two or more guanidinium units^{1,2} or metal cations coordinated via appropriate *N*-ligands.³ However, no examples of calix[4]arenes decorated with these two different units are reported in the literature. We therefore synthesized the guanidino-triazacyclononane-calix[4]arene **1**(H⁺)₄ to test the ability of its Zn^{II} and Cu^{II} complexes to cleave phosphodiesterases⁴. These systems show high activity in the cleavage of the RNA model HPNP thanks to the cooperation of the two units at the upper rim (**Figure 1**). The monoprotonated species **1**H⁺-Zn^{II} and **1**H⁺-Cu^{II} enhance the intramolecular transesterification rate by 2.1·10³ and 3.2·10⁵ folds, respectively. The catalytic activities, measured in DMSO/H₂O (80/20) at different pH values, show a maximum at pH 8.8 for **1**H⁺-Cu^{II} and 9.8 for **1**H⁺-Zn^{II}. Potentiometric titrations point out that at these pH values the deprotonation of a water molecule coordinated to the metal center takes place, thus supporting the hypothesis that a metal ion-coordinated hydroxide ion participates to the catalytic process. The most reactive **1**H⁺-Cu^{II} was also tested in the cleavage of some diribonucleoside monophosphates, leading, in the case of GpA, to an acceleration factor of 1.3·10⁷-fold.

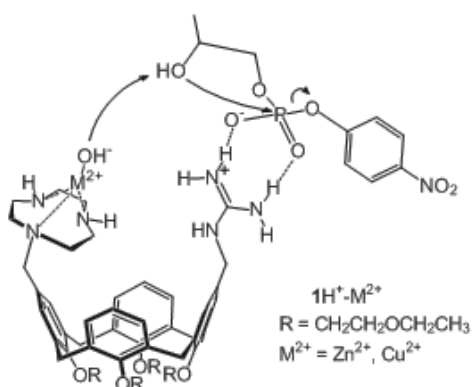


Figure 1. Mechanism proposed for intramolecular transesterification of HPNP by **1**H⁺-M²⁺

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Ringraziamenti

Magnifico Rettore dell'Università di Parma, Prof. Loris Borghi

Fondazione Cariparma

Dott.ssa Caterina Agrimonti (Dip. di Bioscienze)

Sig. Francesco Azzoni (Dip. di Bioscienze)

Dott.ssa Urbana Bonas (Dip. di Bioscienze)

Dott.ssa Valentina Buffagni (Dip. di Bioscienze)

Dott.ssa Marina Caldara (Dip. di Bioscienze)

Dott.ssa Stefania Cadonici (Dip. di Bioscienze)

Dott.ssa Claudia Caselli (Dip. di Bioscienze)

P.I. Mimmo Cavalca (Dip. di Bioscienze)

Dott. Nicola Cvirani (Dip. di Bioscienze)

Sig.ra Simona Fontana (Dip. di Bioscienze)

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Dott.ssa Laura Paesano (Dip. di Bioscienze)

Dott. Francesco Pasquali (Dip. di Bioscienze)

Dott.ssa Graziella Pira (Dip. di Bioscienze)

Ing. Marco Pola (IMEM-CNR, Parma)

Sig.ra Antonella Secondulfo (IMEM-CNR, Parma)

Sig. Vanni Villa (Università di Parma)

