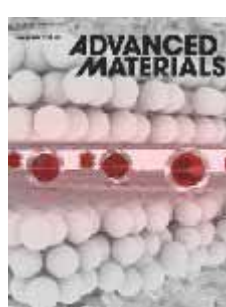
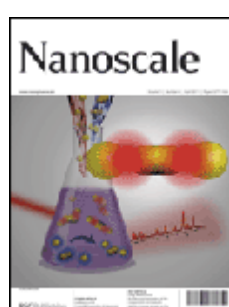
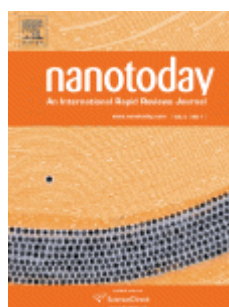


# Annual Research Report

January – December 2011



Universidade de Vigo





May 2011

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**Luis M. Liz-Marzán**  
Professor, Physical Chemistry  
Universidade de Vigo  
36310, Vigo, Spain

Tel. (+34) 986 812 298 Fax (+34) 986 812 556  
E-mail: [lmarzán@uvigo.es](mailto:lmarzán@uvigo.es)  
<http://webs.uvigo.es/coloides/nano>

## Research Program

The research activity of the Colloid Chemistry Group is focused on the synthesis and formation mechanisms of metal, semiconductor, magnetic and hybrid nanoparticles with controlled composition, size and morphology; the creation of colloidal composites, including functionalized carbon nanotubes; nanostructured thin films and nanoparticle ordered arrays in two and three dimensions; the optical characterization of nanoparticles and their assemblies; and the use of metal nanoparticles as biosensors.

## External Collaborators

P. Mulvaney (U. Melbourne, Australia)  
J. García de Abajo, (IO, CSIC, Spain)  
D. Carlos (U. Aveiro, Portugal)  
M. Edirisinghe (UC London, UK)  
N. A. Kotov (U. Michigan, USA)  
F. Caruso (U. Melbourne, Australia)  
M. Prato (U. Trieste, Italy)  
Míguez (ICMSE, CSIC, Spain)  
J. Colmenero (U. Basque Country, Spain)  
A. de Luca (CNR-IPCF, Italy)  
Mews (U. Hamburg, Germany)  
S. Sortino (U. Catania, Italy)  
J. Pérez-Gil (U. Complutense, Spain)

M. Giersig (FU Berlin, Germany) F.  
F. Vallée (CNRS, Lyon, France) L.  
C. López (ICMM, CSIC, Spain)  
T. Hellweg (U Bielefeld, Germany)  
M. Kociak (CNRS Orsay, France)  
C. Abell (U. Cambridge, UK)  
A. Fery (U. Bayreuth, Germany) H.  
S. Bals (U. Antwerp, Belgium)  
A. Corma (UPV-CSIC, Spain)  
W. Parak (U. Marburg, Germany) A.  
O. Spalla (CEA Saclay, France)  
N. Buurma (U. Cardiff, UK)  
N. Pina (U. Aveiro, Portugal)

## Collaborators at Universidade de Vigo

A. Rodríguez de Lera (Organic Chemistry)  
J. L. Alonso-Gómez (Organic Chemistry)

## Postdoctoral Research Associates

Pablo Hervés-Beloso (faculty)  
J. Benito Rodríguez González (permanent)  
Miguel A. Correa-Duarte (faculty)  
Moisés Pérez-Lorenzo (long term)  
Paula C. Angelomé (Oct 2008-present)  
Jose M. Romo Herrera (April 2010-April 2012)  
Enrique Carbó Argibay (June 2011-present)

Isabel Pastoriza-Santos (faculty)  
Jorge Pérez-Juste (faculty)  
Ramón A. Alvarez Puebla (long term)  
Andrés Guerrero-Matínez (long term)  
A. K. Samal (Sep 2011-present)  
Munish Chanana (May 2010-present)  
Manuel Martins (Oct 2011-present)

## Graduate Students

Ana Claudia Lobao  
M. Fernanda Cardinal  
Marcos Sanles-Sobrido  
Laura Rodríguez-Lorenzo  
Cintia Mateo-Mateo  
Sergio Gómez-Graña  
Marcin Grzelczak  
Alejandro Alvarez-Paneque

M. Carmen Vázquez-Vázquez  
Patricia Taladriz-Blanco  
Sara Abalde-Cela  
Dionysia Tsoutsi  
Paula Aldeanueva-Potel  
Denis Rodríguez-Fernández  
Silvia Fernández-Vázquez  
Vanesa López-Puente

## Scientific Administrator

Gema Antequera-García

## Technicians

Ana M. Sánchez-Iglesias  
Cristina Fernández-López  
Oscar Ameneiro-Prieto

## Visiting students to conduct experiments or extend collaboration

Malte Stroizyk (U. Mainz, Germany)  
Andrea Cabrera (U. California, USA)  
Antonio Luis Medina-Castillo (University of Granada, Spain)  
M. Carmen López (ICM Sevilla-CSIC, Spain)  
Denis Mongin (University of Lyon 1, France)  
Ilaria Mannelli (CISC-BCN-IQAC, Spain)  
Rubén Ahijado-Guzmán (CIB-CSIC, Spain)  
Steven Barrow (University of Melbourne, Australia)  
Valentina Rebutini (University of Aveiro, Portugal)  
Vivian Merk (University of Duisburg-Essen, Germany)  
Ludivine Malassis (University of Boudeaux 1, France)  
Mengistie Leweyehu (University of Aveiro, Portugal)

## Research Visitors/ Seminars

Joao Mano (University of Minho, Portugal)  
Francesco Stellacci (EPFL Lausanne, France)  
James H. Dickerson (Vanderbilt University, USA)  
Ana Otero (University of Santiago de Compostela, Spain)  
Olivier Spalla (CEA Saclay, France)  
Roberto Cao Vázquez (University of La Habana, Cuba)  
Jose Luis Mascareñas (University of Santiago de Compostela, Spain)  
David Avila Brande (University Complutense, Spain)  
Brad Chemelka (University of California Santa Barbara, USA)  
Dangheng Su (Fritz Haber Institute of the Max Planck Society, Berlin)  
Georgina K. Such (University of Melbourne, Australia)  
Gustavo Bodelón-González (CNB-CSIC, Spain)  
Wolfgang Schärfl (University of Mainz, Germany)

## Research Funding

European Commission (*FP7: NANODIRECT, INGENIOUS, METACHEM*)  
ERC Advanced Grante (*PLASMAQUO*)  
Ministerio de Ciencia e Innovación  
NanoBioMed (Consolider-Ingenio 2010)  
Xunta de Galicia  
Universidade de Vigo  
Agencia Española de Cooperación Internacional

## Awards

- Isabel Pastoriza Santos has received the L'Oreal grant.
- Luis M. Liz Marzán has been recognized with the Burdinola Research Award.
- Luis M. Liz Marzán has been featured as Pontevedrian of the year 2010.

## Professional Activities (L.M. Liz-Marzán)

- **Senior Editor**, *Langmuir* (ACS)
- **Member**, Editorial Board, *Journal of Materials Chemistry* (RSC)
- **Member**, Editorial Board, *Journal of Physical Chemistry* (ACS)
- **Member**, Editorial Board, *Nano Today* (Elsevier)
- **Member**, Editorial Board, *Science of Advanced Materials* (ASP)
- **Member**, Editorial Board, *Theranostics* (Ivyspring)
- **Member**, Editorial Board, *ChemistryOpen* (Wiley-VCH)
- **Member**, Science Board, *Biobanco CHUVI*
- **Member**, Subcommittee 9, *Institut Laue-Langevin*

## Organization of Conferences and Workshops

The Colloid Chemistry Group organized the **Workshop on Nanoplasmonics for Energy and the Environment**, in Sanxenxo (near Vigo), from 8 to 10 June, 2011.

The workshop program included 29 invited talks, as well as 80 poster communications, with a total number of 130 participants from over 12 countries. The workshop became a high level discussion forum, concerning processes related to the interaction of light with metallic nanostructures (nanoplasmonics). The topics included synthesis methods, theoretical modelling and advanced techniques for characterization of plasmon modes in single nanoparticles, electron transfer between nanoparticles and molecules, applications in photovoltaics, detection techniques (LSPR, SERS), therapeutic applications, or the impact of nanoparticles in the environment. We would like to thank all speakers and participants for their contributions to the success of this workshop.



Workshop photo at Praia de A Lanzada

The Colloid Chemistry Group additionally organized the **Workshop on Nanostructured Materials for Sensing, in Vigo, April 13<sup>th</sup>**

The workshop program included 11 invited talks, with a total number of 50 participants.

**Luis M. Liz-Marzán served in the scientific committees for several conferences:**

**International Symposium on Metastable, Amorphous and Nanostructured Materials**  
Gijón (Spain), June 26 – July 1, 2011

**4<sup>th</sup> Iberian Meeting on Colloids and Interfaces**  
Porto, July 12 – 14, 2011

**25th European Colloid and Interface Society Meeting**  
Berlin, September 4 – 9, 2011

**XXXIII Reunión Bienal de la Real Sociedad Española de Física**  
Santander (Spain), September 19 – 23, 2011

## **Invited Lectures at Conferences, Courses and Workshops**

**Luis M. Liz-Marzán**

### **Multifuncntional Composite Colloidal Microgels**

Australian Colloid and Interface Society Meeting  
Hobart (Australia), January 30-February 3, 2011

Engineering metal nanoparticles for environmental monitoring  
241st American Chemical Society National Meeting and Exposition  
Anaheim (USA), March 27-31, 2011

### **Hot Spot and confinement in metal nanoparticles and assemblies**

IMAGENENANO 2011  
Bilbao (Spain), April 11–14, 2011

### **Multifunctional Composite Colloidal Microgels**

MRS Spring Meeting  
San Francisco (USA), April 25-29, 2011

### **Growth and directional assembly of anisotropic gold nanoparticles**

Colloids and Materials 2011  
Amsterdam (The Netherlands), May 8-11, 2011

### **Plenty of room in the world of neglected dimensions**

Jornadas de Biofísica  
Ourense (Spain), May 26, 2011

### **Nanochemistry for nanotechnology**

Minilubes Scientific Fellows' Congress  
Vigo (Spain), June 1-3, 2011

### **Toward directed assembly of plasmonic nanoparticles and nanorods**

Gordon research Conferences 2011  
Lucca (Italy), June 19-24, 2011

### **Synthesis, assembly and applications of plasmonic metal nanoparticles**

IV School on Organometallic Chemistry "Marcial Moreno Mañas"  
Santiago de Compostela (Spain), June 27-29, 2011

### **Responsive microgel composite colloids for plasmonic sensing**

Particles 2011  
Berlin (Germany), July 9-12, 2011

### **Ensamblaje dirigido en la nanoescala**

Reunión Bienal de la RSEQ  
Valencia (Spain), July 25–29, 2011

### **Novel strategies for generalized SERS detection**

V Workshop NyNA 2011  
Toledo (Spain), September 21-23, 2011

### **Engineering metal nanoparticles for plasmonic sensing systems based on plasmonic phenomena resonance**

Rusnanotech 2011

Moscow (Russian Federation), October 26-28, 2011

**Los colores de la nanotecnología: belleza y utilidad**

Maratón Científico de Química  
Oviedo (Spain), November 7, 2011

**Nanoquímica. Una nueva visión de la Química** (Plenaria)

Encontro Galego-Portugués de Química  
Pontevedra (Spain), November 10–11, 2011

**Ultrasensitive analysis using metal nanoparticles**

13as Jornadas de Análisis Instrumental  
Barcelona (Spain), November 14-16, 2011

***Engineering metal nanoparticles for plasmonic sensing*** (Plenary)

CeNTech Science Day  
Münster (Alemania), November 28, 2011

**Anisotropic Assembly of Gold Nanoparticles**

2nd NanoToday Conference  
Kona, Hawaii (USA), December 11-15, 2011

**Ramón Álvarez Puebla**

**Direct and Indirect strategies for SERS Bio-Applications**

Nanomaterial-Based Sensors for Biomedical Applications  
Melbourne (Australia), March 17-18, 2011

**Desing of hybrid plasmonic materials for SERS direct and indirect sensing**

2011 Optics + Photonics  
San Diego (USA), August 21-25, 2011

**Materiales híbridos avanzados y sus aplicaciones como sensores ópticos**

XXXIII Reunión Bienal de la RSEQ  
Valencia (Spain), July 25-26, 2011

**Isabel Pastoriza-Santos**

**Gold and silver nanoparticles: Synthesis and applications**

Symposium nanoLCA: Safety Issues of Nanomaterials along their life cycle  
Barcelona (Spain), May 4-5, 2011

**Nanocomposites based on a Au core and a pNIPAM shell for molecular sensing.**

Workshop on «Materials and Devices for chemical sensing».  
Photochemistry Center RAS, October 5, 2011

## **Invited Seminars at Research Institutions**

**Luis M. Liz-Marzán**

### **Crecimiento y cristalografía de metales en escala nanométrica**

Universidad de Barcelona (Feb 2011)

### **Directing the growth and assembly of metal nanocrystals in solution**

Instituto de Ciencia de Materiales de Barcelona (ICMAB-CSIC) (Apr 2011)

### **Synthesis, assembly and applications of plasmonic nanoparticles**

University of California, Santa Cruz (Apr 2011)

### **Materiales con propiedades "a la carta": Cuestión de escala**

Universidad de Vigo (Ciclo Año Internacional de la Química), (May 2011)

### ***The Growth Mechanisms of Metal Nanocrystals***

Universität Mainz (May 2011)

### **Algunas aplicaciones de la nanotecnología a las ciencias de la vida**

Fundación Hospital de Madrid (Jun 2011)

### **Engineering nanoplasmonic colloids**

Max-Planck-Institute of Colloids and Interfaces, Golm (Aug 2011)

### **Engineering plasmonic colloids for SERS detection**

Universität Bayreuth (Aug 2011)

### **Morphology control and directed assembly of colloidal plasmonic nanoparticles**

Universität Jena (Aug 2011)

### **Assembly and encapsulation of metal nanocrystals for detection applications**

Helmholtz Zentrum Berlin, (Sep 2010)

### **Nanomateriales "a la carta" para detección y diagnóstico**

Universidad de Oviedo, Conferencias Aula Magna (Oct 2011)

### **Directing the Growth and Structure of Gold Nanocrystals**

ETH Zürich (Oct 2011)

### **Nanomateriales a la carta para detección y diagnóstico**

Universidad de La Habana, (Nov 2011)

## Research Publications

- A. Guerrero-Martínez, J. Pérez-Juste, L.M. Liz-Marzán
- 30. Plasmon Mode Selection Through Orientated Assembly of Gold Nanorods**  
*EPA Newsletter*, June 2011, 46-48
- R.A. Alvarez-Puebla, L.M. Liz-Marzán
- 29. Medical applications of plasmonic nanoparticles**  
In: *Nanomedicine – Basic and Clinical Application in Diagnostics and Therapy*, Karger (Else Kröner-Fresenius Symposia), Vol. 2, 2011, pp. 106-115
- X. Ma, K. Fletcher, T. Kipp, M.P. Grzelczak, Z. Wang, A. Guerrero-Martínez, I. Pastoriza-Santos, A. Kornowski, L.M. Liz-Marzán, A. Mews
- 28. Photoluminescence of individual Au/CdSe nanocrystal complexes with variable interparticle distances**  
*J. Phys. Chem. Lett.* 2011, 2, 2466-2471
- D. Tsoutsi, J.M. Montenegro, F. Dommershausen, U. Koert, L.M. Liz-Marzán, W.J. Parak, R.A. Alvarez-Puebla
- 27. Quantitative SERS ultradetection of atomic inorganic ions: the case of chlorine**  
*ACS Nano* 2011, 5, 7539-7546
- P. Taladriz-Blanco, N.J. Buurma, L. Rodríguez-Lorenzo, J. Pérez-Juste, L.M. Liz-Marzán, P. Hervés
- 26. Reversible assembly of metal nanoparticles induced by penicillamine. Dynamic formation of SERS hot spots**  
*J. Mater. Chem.* 2011, 21, 16880-16887
- L. Rodríguez-Lorenzo, Z. Krpetic, S. Barbosa, R.A. Alvarez-Puebla, L.M. Liz-Marzán, I.A. Prior, M. Brust
- 25. Intracellular mapping with SERS-encoded gold nanostars**  
*Integrative Biol.* 2011, 9, 922-926
- N. Pazos-Perez, T. Borke, D.V. Andreeva, R.A. Alvarez-Puebla
- 24. Silver coated aluminium microrods as highly colloidal stable SERS platforms**  
*Nanoscale* 2011, 3, 3265-3268
- A. Guerrero-Martínez, J.L. Alonso-Gómez, B. Auguie, M.M. Cid, L.M. Liz-Marzán,
- 23. From individual to collective chirality in metal nanoparticles**  
*Nano Today* 2011, 6, 381-400
- M. Chanana, M.A. Correa-Duarte, L.M. Liz-Marzán
- 22. Insulin coated Gold NPs - A Plasmonic Device for Studying Protein-Metal Interactions**  
*Small* 2011, 7, 2650-2660
- A. De Luca, M.P. Grzelczak, I. Pastoriza-Santos, L.M. Liz-Marzán, M. La Deda, M. Striccoli, G. Strangi
- 21. Dispersed and Encapsulated Gain Medium in Plasmonic Nanoparticles: a Multipronged Approach to Mitigate Optical Losses**  
*ACS Nano* 2011, 5, 5823-5829
- L. Alves, B. Ballesteros, M. Boronat, J.R. Cabrero-Antonino, P. Concepcion, A. Corma, M.A. Correa-Duarte, E. Mendoza
- 20. Synthesis and Stabilization of Subnanometric Gold Oxide Nanoparticles on Multiwalled Carbon Nanotubes and Their Catalytic Activity**  
*J. Am. Chem. Soc.* 2011, 133, 10251-10261
- S.L. Ng, G.K. Such, A.P.R. Johnston, G. Antequera-García, F. Caruso
- 19. Controlled release of DNA from poly(vinylpyrrolidone) capsules using cleavable linkers**  
*Biomaterials* 2011, 32, 6277-6284

- D. Mongin, V. Juvé, P. Maioli, A. Crut, N. Del Fatti, F. Vallée, A. Sánchez-Iglesias, I. Pastoriza-Santos, L.M. Liz-Marzán
18. **Acoustic vibrations of metal-dielectric core-shell nanoparticles**  
*Nano Letters* **2011**, *11*, 3016-3021  
N.K. Reddy, J. Perez-Juste, I. Pastoriza-Santos, P.R. Lang, J.K.G. Dhont, L.M. Liz-Marzán, J. Vermant
17. **Flow Dichroism as a Reliable Method to Measure the Hydrodynamic Aspect Ratio of Gold Nanoparticles**  
*ACS Nano* **2011**, *5*, 4935-4944  
R.A. Alvarez-Puebla, A. Agarwal, P. Manna, B.P. Khanal, P. Aldeanueva-Potel, E. Carbó-Argibay, N. Pazos-Pérez, L. Vigderman, E.R. Zubarev, N.A. Kotov, L.M. Liz-Marzán
16. **Gold Nanorods 3D-Supercrystals as SERS substrates for the Rapid Detection of Scrambled Prions**  
*Proc. Natl. Acad. Sci. USA* **2011**, *108*, 8157-8161  
L. Rodríguez-Lorenzo, J.M. Romo-Herrera, J. Pérez-Juste, R.A. Alvarez-Puebla, L.M. Liz-Marzán
15. **Reshaping and LSPR tuning of Au nanostars in the presence of CTAB**  
*J. Mater. Chem.* **2011**, *21*, 11544-11549  
A. Guerrero-Martínez, B. Auguie, J.L. Alonso-Gómez, Z. Džolić, S. Gómez-Graña, M. Žinić, M.M. Cid, L.M. Liz-Marzán
14. **Intense Optical Activity via 3D Chiral Ordering of Plasmonic Nanoantennas**  
*Angew. Chem. Int. Ed.* **2011**, *50*, 5499-5503  
O. Sánchez-Sobrado, G. Lozano, M.E. Calvo, A. Sánchez-Iglesias, L.M. Liz-Marzán, H. Míguez
13. **Interplay of resonant cavity modes with localized surface plasmons: optical absorption properties of Bragg stacks integrating gold nanoparticles**  
*Adv. Mater.* **2011**, *23*, 2108-2112  
S. Mazzuco, O. Stéphan, I. Pastoriza-Santos, L.M. Liz-Marzán, F.J. García de Abajo, M. Kociak
12. **Spatially resolved measurements of plasmonic eigenstates in complex-shaped, asymmetric nanoparticles: gold nanostars**  
*Eur. Phys. J. D* **2011**, *54*, 33512  
A. Guerrero-Martínez, R.A. Alvarez-Puebla, L.M. Liz-Marzán
11. **Nanoplasmónica Basada en Química Coloidal**  
*Anales de Química* **2011**, *17*, 221-228  
S. Abalde-Cela, J.M. Hermida-Ramón, P. Contreras-Carballada, L. De Cola, A. Guerrero-Martínez, R.A. Alvarez-Puebla, L.M. Liz-Marzán
10. **SERS Chiral Recognition and Quantification of Enantiomers through Cyclodextrin Supramolecular Complexation**  
*ChemPhysChem* **2011**, *12*, 1529-1535  
M. Karg, S. Wellert, S. Prevost, R. Schweins, C. Dewhurst, L.M. Liz-Marzán, T. Hellweg
9. **Well defined hybrid PNIPAM core-shell microgels: size variation of the silica nanoparticle core**  
*Colloid Polym. Sci.* **2011**, *289*, 699-709  
B. Auguie, J.L. Alonso-Gómez, A. Guerrero-Martínez, L.M. Liz-Marzán
8. **Fingers crossed: circular dichroism with a dimer of plasmonic nanorods**  
*J. Phys. Chem. Lett.* **2011**, *2*, 846-851  
R. Contreras-Cáceres, S. Abalde-Cela, P. Guardia-Girós, A. Fernández-Barbero, J. Pérez-Juste, R.A. Alvarez-Puebla, L.M. Liz-Marzán
7. **Multifunctional microgel magnetic/optical traps for SERS ultradetection**

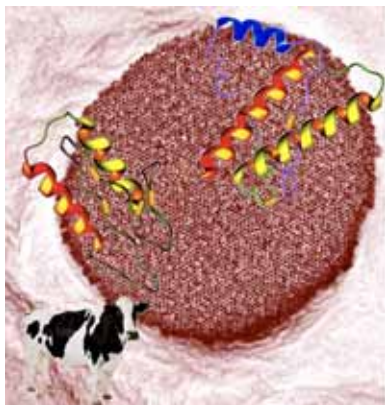
- Langmuir* **2011**, *27*, 4520-4525  
V.M. Boucher, D. Cangialosi, A. Alegría, J. Colmenero, I. Pastoriza-Santos, L.M. Liz-Marzán
- 6. Physical aging of polystyrene/gold nanocomposites and its relation to the calorimetric Tg depression**  
*Soft Matter* **2011**, *7*, 3607-3620  
A. Guerrero-Martínez, S. Barbosa, I. Pastoriza-Santos, L.M. Liz-Marzán
- 5. Nanostars shine bright for you. Colloidal synthesis, properties and applications of branched metallic nanoparticles**  
*Curr. Op. Colloid Interface Sci.* **2011**, *16*, 118-127  
J.M. Romo-Herrera, R.A. Alvarez-Puebla, L.M. Liz-Marzán
- 4. Controlled Assembly of Plasmonic Colloidal Nanoparticle Clusters**  
*Nanoscale* **2011**, *3*, 1304-1315 (RSC's one millionth paper)  
V.M. Boucher, D. Cangialosi, A. Alegría, J. Colmenero, J. González-Irún, L.M. Liz-Marzán
- 3. Physical aging in PMMA/silica nanocomposites: Enthalpy and dielectric relaxation**  
*J. Noncryst. Solids* **2011**, *357*, 605-609  
F. Martínez-Julián, S. Ricart, A. Pomar, M. Coll, P. Abellán, F. Sandiumenge, M.J. Casanove, X. Obradors, T. Puig, I. Pastoriza-Santos, L.M. Liz-Marzán
- 2. Chemical Solution Approaches to YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7-δ</sub> – Au Nanocomposite Superconducting Thin Films**  
*J. Nanosci. Nanotech.* **2011**, *11*, 3245-3255  
S. Abalde-Cela, B. Auguie, M. Fischlechner, W.T.S. Huck, R.A. Alvarez-Puebla, L.M. Liz-Marzán, C. Abell
- 1. Microdroplet fabrication of silver-agarose nanocomposite beads for SERS optical accumulation**  
*Soft Matter* **2011**, *7*, 1321-1325

## Abstracts of Selected Publications

*P. Natl. Acad. Sci. USA* **2011**, *108*, 8157-8161

### **Real-Time Detection of Scrambled Prions on 3D Supercrystals of Gold Nanorods**

R.A. Alvarez-Puebla, A. Agarwal, B.P. Khanal, P. Aldeanueva-Potel, E. Carbó-Argibay, N. Pazos-Pérez, E.R. Zubarev, N.A. Kotov, L.M. Liz-Marzán

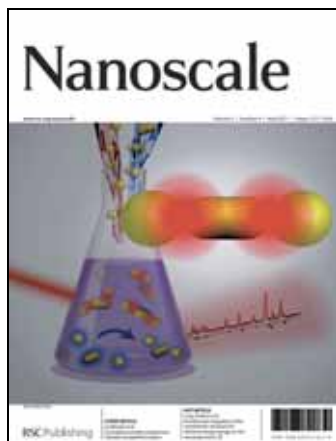


Highly organized supercrystals of Au nanorods with plasmonic antennae enhancement of electrical field have made possible fast direct detection of prions in complex biological media such as serum and blood. The nearly perfect three-dimensional organization of nanorods render these systems excellent SERS substrates with uniform electric field enhancement, leading to reproducibly high enhancement factor in the desirable spectral range.

*Nanoscale*, **2011**, *3*, 1304-1315

### **Controlled assembly of plasmonic colloidal nanoparticle clusters**

J.M. Romo-Herrera, R.A. Alvarez-Puebla, L.M. Liz-Marzán



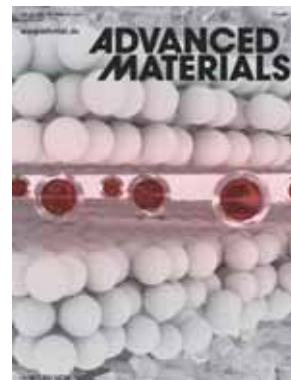
Coupling of localized surface plasmon resonances results in singular effects at the void space between noble metal nanoparticles. However, implementation of practical applications based on plasmon coupling calls for the high yield production of metal nanoparticle clusters (dimers, trimers, tetramers,..) with small gaps. Therefore, controlled assembly using colloid chemistry methods is an emerging and promising field. We present a brief overview over the controlled assembly of plasmonic nanoparticle clusters by colloid chemistry methods, together with a description of their plasmonic properties and some applications, with an emphasis in sensing through surface-enhanced Raman scattering spectroscopy for bio-detection purposes. We point out the important role of separation methods to obtain colloidal clusters in high yield. A special encouragement to explore assembly of anisotropic building blocks is pursued.

*Adv. Mater.* **2011**, *23*, 2108-2112

### **Interplay of Resonant Cavity Modes with Localized Surface Plasmons: Optical Absorption Properties of Bragg Stacks Integrating Gold Nanoparticles**

O. Sánchez-Sobrado, G. Lozano, M.E. Calvo, A. Sánchez-Iglesias, L.M. Liz-Marzán, H. Míguez

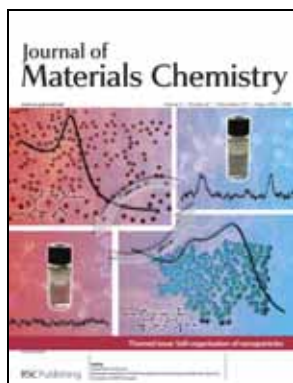
We have shown that the interplay between localized surface plasmons of gold nanoparticles and the field confinement effects that occur in the optical resonators containing them can be used to achieve spectrally selective enhancement of the optical absorption of the ensemble. It was also demonstrated that the porous nature of the final hybrid material provides a means to precisely control the absorption spectrum of the multilayer as a function of the refractive index of the guest compounds. These novel hybrid plasmonic-photonic materials might provide new ways of controlling the optical response stemming from localized surface plasmon resonances in metal particles.



*J. Mater. Chem.*, 2011, **21**, 16880-16887

### **Reversible assembly of metal nanoparticles induced by penicillamine. Dynamic formation of SERS hot spots**

P. Taladriz-Blanco, N.J. Buurma, L. Rodríguez-Lorenzo, J. Pérez-Juste, L.M. Liz-Marzán, P. Hervés

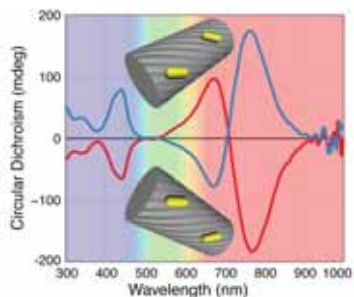


We report a systematic study of the surface modification of gold and silver nanoparticles with DL-penicillamine (PEN) and *N*-acetyl-DL-penicillamine (NAP), motivated by the possibility of inducing pH-controlled reversible nanoparticle assembly. The interaction of PEN and NAP with the metal nanoparticle surface was studied by isothermal titration calorimetry (ITC). The results indicate that equilibrium is reached with the formation of a submonolayer corresponding to ca. 40% and 64% of total surface coverage for PEN and NAP, respectively. Both PEN and NAP modified nanoparticles could be reversibly aggregated at acidic pH due to the protonation of the carboxylic groups, leading to a decrease in their stability by electrostatic interactions and the advent of hydrogen bonding interactions which promote interparticle linkage. Interestingly, the SERS characterization demonstrated the pH-controlled formation of hot-spots.

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### **Intense Optical Activity via 3D Chiral Ordering of Plasmonic Nanoantennas**

A. Guerrero-Martinez, B. Auguie, J.L. Alonso-Gomez, Z. Džolic, S. Gómez Graña, M. Žinic, M.M. Cid, L.M. Liz-Marzán

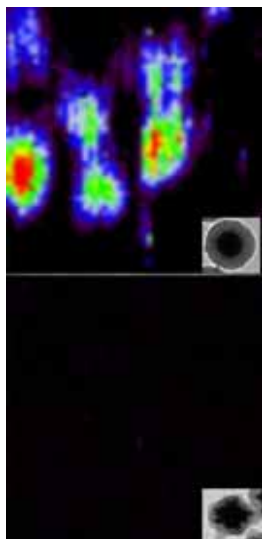


Plasmonic circular dichroism was experimentally obtained in chiral 3D organisations of gold nanorods, obtained by self-assembly of the nanoantennas onto a fibre template with twisted morphology. Circular dichroism measurements revealed intense plasmon-induced Cotton effect, and the highest reported anisotropy factor for metal nanoparticles in fluid suspensions. Numerical simulations based on coupled-dipoles confirm the crucial role of gold nanorods in this intense circular dichroism.

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### **Intracellular mapping with SERS-encoded gold nanostars**

L. Rodríguez-Lorenzo, Z. Krpetic, S. Barbosa, R.A. Alvarez-Puebla, L.M. Liz-Marzán, I.A. Prior, M. Brust



Here we report on the design, synthesis and application of small, highly bright, star-shaped SERS encoded single nanoparticles with the ability of providing an optical signal upon excitation with near infrared light. These particles are colloiddally stable, fully biocompatible and can be internalized into living cells for intracellular imaging.