

# Marie Skłodowska-Curie Post-doc Positions in UNISI: “Expression of Interest” for hosting Marie Skłodowska-Curie Fellows

This template should be used by Professor/Doctor interested in hosting post-doctoral fellows within the Marie Skłodowska-Curie fellowship programme.

## 1. Short Description of the Project idea

Synthetic Cells (SCs) can be defined as cell-like molecular systems constructed in the laboratory by inserting biological or synthetic molecules inside and on the surface of lipid vesicles (liposomes). Ideally, SCs mimic biological cells with respect to structure, functions, interactions, and any other possible property with minimal complexity. SCs can be created and adapted for investigating biological mechanism or developing biotechnological tools and they can also be relevant in origin of life studies because they are useful models of primitive cells (protocells). Among the others, the study and the modelling of functions like the vesicle “self-replication” and “self-division” can be of interest both for gaining biological insights and for practical and technological applications.

In this project, we aim at constructing a biomimetic artificial compartment, in the micrometer scale (10 – 50  $\mu\text{m}$  in diameter), that can undergo self-division and/or self-replication following an internal (time programmable) stimulus driven by an autocatalytic clock reaction.

Division processes can occur due to the relatively simple action of physicochemical forces, therefore, in order to catch the essential phenomena at play, it would be desirable to work with a purely chemical environment, avoiding the use of complex biomolecules. In this perspective, we devised a pH-responsive compartment based on a mixture of phospholipids and fatty acids able to respond to pH stimuli, triggered by nonlinear chemical clock reactions. The reaction can raise the pH inside the compartment from  $\sim 6$  to  $\sim 10$ , thus deprotonating the fatty acid (that will be chosen with a  $\text{pK}_a = \sim 8$ ), and, in turn, destabilizing the membrane. This process, in fact, will generate a surface-tension driven instability (Marangoni or Rayleigh-Plateau) that will lead to the vesicles swelling and eventually to a division. The use of a clock reaction to change the pH has a great advantage. The clock time, i.e. the time at which the autocatalytic process takes place, is a function of the reactants concentration, therefore the division process can be programmed in time. In case of successful experiments, this aspect is particularly relevant for medical and/or technical applications.

### Milestones

1. Synthesis of phospholipid-fatty acid mixed giant vesicles
2. Characterization of the autocatalytic reaction

3. Encapsulation of the clock reaction into the vesicles
4. Characterization and tuning of the experimental systems

**2. DEPARTMENT/LABORATORY (Describe briefly the department/laboratory, where the researcher will be employed, including the research team expertise)**

**Available lab facilities:**

TEM/EDS lab (JEOL 2010)

TEM sample preparation lab (PIPS, Duo Mill for Ar<sup>+</sup> ion milling)

SEM/EDS lab

Optical microscopy lab (polarized light, transmitted and reflected light, 3D KH 7700 Hirox),

X ray Powder Diffraction (XRPD) lab

Chemical lab.

HPLC

Taylor Dispersion Analysis

**3. Position, scientific requirements (es. n of publications), topic, discipline\*:**

We seek a candidate for an experimental **Post-doc Position**, who owns a PhD in Chemical Science.

\*Please tick: (according to scientific subject areas, defined by MSCA)

Life Sciences

Natural Sciences

Engineering Sciences

**X Chemistry**

**4. DESCRIPTION OF THE SUPERVISOR (max. 200 words )/Contact person: (name and e-mail address)/**

Prof. Federico Rossi graduated with honors from the University of Siena in 2003 with a thesis entitled "Effect of inert electrolytes on the transient chaos in the Belousov-Zhabotinsky reaction" (Supervisor Prof. Enzo Tiezzi). In the same University he received his PhD title in 2007 with a thesis entitled "On the dynamics of pattern formation in biomimetic systems" (Tutor Prof. Enzo Tiezzi). After the PhD, Dr. Rossi spent three years as Post-Doc at the Department of Physical Chemistry, University of Palermo, working on the reactivity of far-from-thermodynamic equilibrium processes in aggregated systems. In 2009 he won a Marie Curie IOF grant and spent two years at the Department of Chemistry at Brandeis University (MA, USA) in the group of Prof. Epstein. In collaboration with Prof. Epstein, Dr. Rossi has developed a technique based on the Taylor dispersion method for the measurement of diffusion coefficients (main and cross) of species in solution diffusing in complex matrices (emulsions, micelles, etc.). From 2012 to 2018 Dr. Federico Rossi was an assistant professor of Environmental Chemistry (CHIM12) at the Department of Chemistry and Biology, University of Salerno, where he taught the course "Laboratory of

Environmental Chemistry" for the degree course in Environmental Assessment and Monitoring. Since 2018, Federico Rossi is Associate Professor of Physical Chemistry at the Department of Earth, Environmental and Physical Sciences of the University of Siena, where he teaches "general chemistry" and "Environmental modeling".

Over the years Prof. Rossi developed a growing interest in the study of chemical systems with complex kinetics (oscillating, excitable, etc.) coupled with transport phenomena (diffusion and dispersion) that applies to problems of pollutant dispersion in aqueous matrices, heterogeneous catalysis for pollutants oxidation and theoretical analysis of networks of diffusively coupled chemical oscillators. For publications, visit:

<https://orcid.org/0000-0002-1854-532X>

## 5. Previous Related Projects / Research Experience

### Pertinent projects funded over the last years:

- 2004, PAR progetti dell'Università di Siena "Modelli chimico-fisici per lo studio dei sistemi complessi" (Chemico-physical models for the studying of complex systems, Siena University grant).
- 2006, 2008, 2015 ESFR Grenoble "Structural evolution induced by a chemical oscillator in biomimetic systems".
- 2008, Marie Curie international Outgoing Fellowship "Cross-Diffusion and pattern formation in reaction diffusion systems". [https://cordis.europa.eu/project/rcn/91928\\_it.html](https://cordis.europa.eu/project/rcn/91928_it.html)
- 2008, SYNTHCELLS: experimental and theoretical strategies to build semi-synthetic cells, Italian National Research minister grant.
- 2012, Environmental far from equilibrium systems.  
<https://docenti.unisa.it/025462/ricerca/progetti?progetto=15454>
- 2014, COST CM1304 "Emergence and Evolution of Complex Chemical Systems".  
<http://www.systemschemistry.com/cm1304/wg3.html>
- 2015, Synthesis of amphiphilic copolymers with controlled architecture.  
<https://docenti.unisa.it/025462/ricerca/progetti?progetto=24766>
- 2016, Synthesis and characterization of pH-sensitive *polymersomers* for drug delivery.  
<https://docenti.unisa.it/025462/ricerca/progetti?progetto=26914>
- 2017, FAABR Italian National Research minister grant for outstanding researchers.  
<https://docenti.unisa.it/025462/ricerca/progetti?progetto=33376>

6. **SPECIFIC REQUIREMENTS/PREFERENCES** (*Describe the specific requirements/preferences for the MSC fellow if necessary for the development/implementation of the project eg. required language, degree field, research experience, etc.*)

The candidate should have a strong background in experimental kinetics and should master the most common analytical techniques (spectrophotometry, chromatography and potentiometry). The candidate should also be confident with optical, and possibly confocal, microscopy. Some knowledge in programming in Matlab is also desirable but not mandatory.

\*Please consider that the preparation of a Marie Skłodowska-Curie proposal requires some time.

\*\*Please consider that the preparation of a Marie Skłodowska-Curie proposal requires some time. Fellow and supervisor have to agree on a project and training opportunities for the fellow. If you want to extend your expression of interest to the third deadline in 2019, just leave this column open.