



**Theoretical and Physical Chemistry Institute
National Hellenic Research Foundation
Vass. Constantinou 48, Athens**

LECTURE

**“From mussel adhesion to novel materials: toughening elastomers
with mussel-inspired metal coordination complexes”**

Dr. Emmanouela Filippidi

**Materials Research Laboratory, University of California,
Santa Barbara, CA, USA**

Thursday, 8 November 2018, 12:00

Seminar room, ground floor, NHRF

From mussel adhesion to novel materials: toughening elastomers with mussel-inspired metal coordination complexes

*Dr. Emmanouela Filippidi
Materials Research Laboratory, University of California,
Santa Barbara, CA, USA*

Marine mussels attach to rocks, each other, and a variety of surfaces via a flat, wide plaque with porous internal architecture, tethered to an extensible collagen-filled thread. The unusually strong adhesion of the plaque, and the thread's ability to withstand fracture have long been attributed to the molecular design of their proteins (mfps) that can form a variety of strong chemical bonds. Inspired by such protein chemistry, we apply it to create novel polymer network structures.

Typically, materials exhibit a trade-off between stiffness and extensibility, ultimately limiting the energy density that can be absorbed before fracture. For example, in single polymer networks, an increase in the cross-link density leads to enhanced Young's modulus, but compromised extensibility. Dynamic reformable bonds and complex network topologies, such as interpenetrating networks, have been used to circumnavigate this issue with moderate success, mainly in a hydrated environment.

Inspired by and transferring the chemistry of the marine mussels, we present a dry, thermoset, single network that circumvents this inherent trade-off of stiffness and extensibility by incorporating sacrificial, reversible, iron-catechol cross-links into a loosely covalently linked network. The linearly elastic stress-strain response of the purely covalent network is transformed into a non-linear, hysteretic and dissipative, but partially reversible response, but without loss of extensibility [1,2]. We attribute this enhancement to the cooperative effects of the increased cross-link density and the chain-restricting ionomeric nanodomains the iron-catecholate complexes form. We will discuss the effect of moisture, oxidation, and future chemistry variations in order to understand the physics of the system.

[1] Toughening elastomers using mussel-inspired iron-catechol complexes. Filippidi et al, *Science*, **358**, 6362, 502-505.

[2] Designing tougher elastomers with ionomers. Winey, *Science*, **358**, 6362, 449-450.