Synthesis and dynamics of slide-ring materials for double networks

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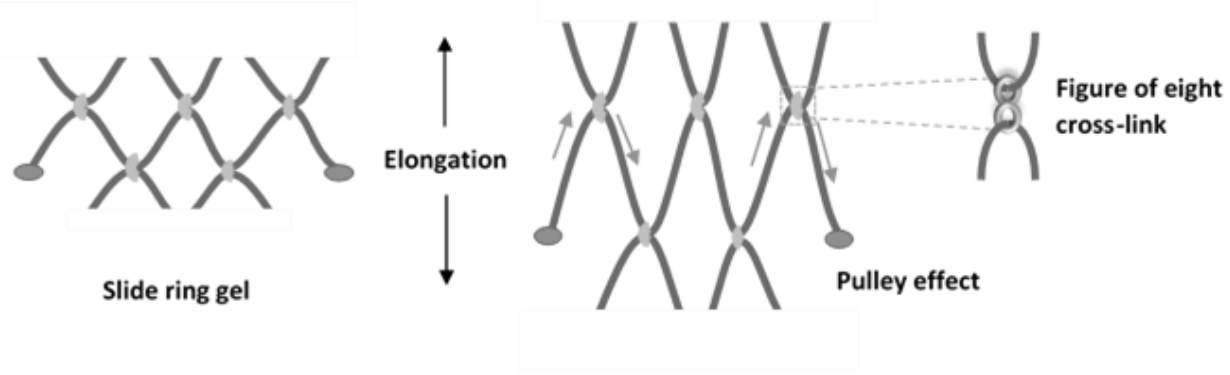
Polymer gels are networks created by cross-linked polymer chains swollen in solution. These links can be either chemical or physical, with consequent effects on the material properties. Both types of networks have advantages and disadvantages: chemical networks resist flow and creep but are difficult to process and recycle, while physical networks are reversible but susceptible to structural changes in the long term. Many solutions have been proposed to improve upon the limitations of conventional gels, among which double networks and slide-ring gels. Double networks are made of two interpenetrating polymer networks: the first is brittle and rigid, and the second is softer and more ductile.[1] The interplay of these traits results in soft materials with "double" mechanical functionality in response to an external stress which is balanced between rigidity and toughness. Slide-ring gels are made of polymer chains held together by figure-of-eight crosslinks (linked macrocycles), each having a polymer chain threaded into its cavity.[2] This allows the rings to move along the polymer chains, the so-called pulley effect, and gives rise to unique properties such high stretchability and high swelling.



In this project, the advantages of double networks and slide-ring gels will be combined to create a new material that is mechanically resistant yet able to dissipate energy. The first, highly crosslinked, network will be based on reversible metal-ligand bonds, while the second will be a slide-ring network. To this aim, polyrotaxanes based on functionalized α-cyclodextrins (CD) and PEG have been synthesized, and used as a crosslinker during N,N-dimethylacrylamide aqueous polymerization. Slide-ring hydrogels of different compositions, e.g. charged or neutral CD, pure PDMAm or use of a charged co-monomer, and crosslinking degrees have been obtained. The rheological and swelling properties of these hydrogels were studied in order to optimize the composition to use them as a soft second network.

[1] Macromol. Chem. Phys. 2016, 217, 1022−1036
[2] Polyrotaxanes & Slide Ring Materials, 2016, Chapter 1 p 1-10, RSC