Hybrid hydrogels based on gelatin, chitosan and functionalized graphene layers

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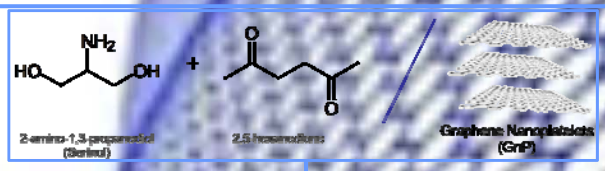
Objectives

- Functionalization of graphene layers, introducing oxygen and nitrogen containing functional groups, without substantially affecting the sp^2 hybridization of carbon atoms.[1-3]
- Preparation of stable water suspensions of few layers graphene and hybrid hydrogels based on gelatin, polyethylene glycol diglycidyl ether, chitosan and graphene layers [4].

2-amino-1,3-propanediol, known as serinol, was the biobased starting building block

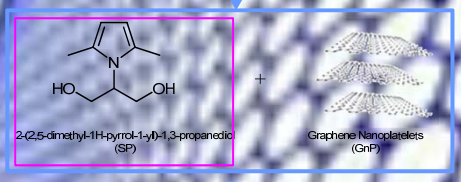


Graphene nanoplatelets (GnP)

	Surface area (m^2/g)
GnP	750

- Yield: at least 96%
- Atom efficiency:85%
- Easy procedure
- No solvent
- By product: H_2O

Paal–Knorr reaction

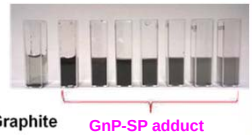


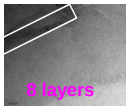
SP: *Janus* molecule

SP:
two hydroxyl groups
promote the compatibility with water

SP:
The pyrrole ring favors the interaction with the aromatic rings of carbon allotropes

Water suspensions of GnP-SP



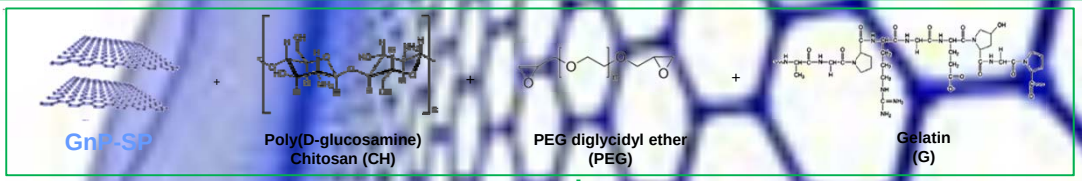


- O_2 as oxidizing agent
- No solvent
- 160°C

Carbocatalyzed Oxidation

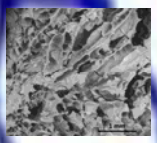
Diels-Alder reaction

Functionalized Graphene Layers (GnP-SP)

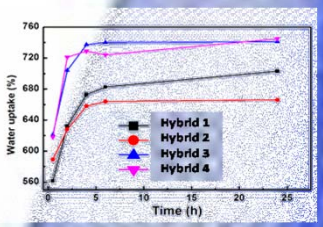


	Graphene content (mass %)
Hybrid 1	/
Hybrid 2	4.6
Hybrid 3	7.2
Hybrid 4	7.4

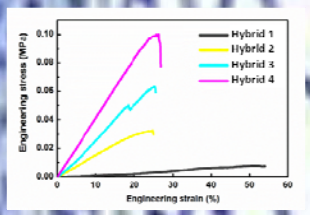
Graphene based hybrid hydrogels



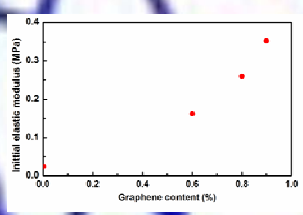
SEM image of the neat hydrogel



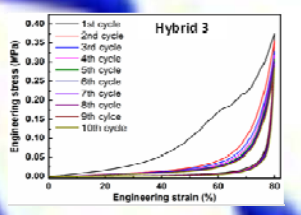
Water uptake of the hydrogels as a function of soaking time



Representative tensile stress-strain curves of wet hydrogels



Initial elastic modulus versus GnP-SP content in the wet samples



compressive cyclic tests carried out on Hybrid 3.

Conclusions

Hybrid hydrogels were prepared, based on gelatin, chitosan, polyethylene glycol diglycidyl ether and graphene nanoplatelets. High water uptake was maintained , with increase of mechanical properties, stiffness and strength, without significant embrittlement. Promising electrical behavior was observed. These results appear important for tissue engineering applications: the use of graphene layers could bring the electrical conductivity suitable for cell growth with electro-mechanical stimuli.

References:

[1] V. Barbera, A. Citterio, M. Galimberti, G. Leonardi, R. Sebastiano, S.U. Shisodia, A.M. Valerio WO 189411 A1, 2015; [2] M. Galimberti, V. Barbera, S. Guerra, L. Conzatti, S. Castiglioni, L. Brambilla, A. Serafini, *RSC Adv.*, **2015,** 5, 81142-81152. [3] Barbera, V., Bernardi, A., Palazzolo, A., Rosengart, A., Brambilla, L., & Galimberti, M. Pure and Applied Chemistry, 90(2), 253-270..[4] Dey, K., Agnelli, S., Serzanti, M., Ginestra, P., Scari, G., Dell'Era, P. & Sartore, L. (2018): International Journal of Polymeric Materials and Polymeric Biomaterials, DOI: 10.1080/00914037.2018.1429439