Chitosan/Graphene Oxide aerogels with controlled porous morphology for water and air purification

Chiara Santillo[a*], Martina Salzano de Luna[a,b], Rachele Castaldo[c], Chiara Ascione[a], Letizia Verdolotti[a], Giovanna G. Buonocore[a], Gennaro Gentile[c] and Marino Lavorgna[a].

[a] Institute for Polymers, Composites and Biomaterials, National Research Council of Italy, P.le E. Fermi 1, 80055 Portici, Italy.
[b] Department of Chemical, Materials and Production Engineering (INSTM Consortium – UdR Naples), University of Naples Federico II, P.le Tecchio 80, 80125 Naples, Italy.
[c] Institute for Polymers Composites and Biomaterials, National Research Council of Italy, Via Campi Flegrei 34, 80078 Pozzuoli, Italy

*chiara.santillo@unina.it

Aerogels have outstanding characteristics, namely high surface area, huge porosity and low density, which make them promising for wide range of applications, such as medical fields, wastewater treatments, environmental pollution and so on. In the environmental field, chitosan (CS)-based aerogels are receiving growing attention due to the biocompatibility and biodegradability properties of this polysaccharide, which make it a green starting material.[1] Moreover, the CS possesses amine and hydroxyl groups that are highly effective in binding anionic pollutants and heavy metals.[1-2] The adsorption properties of this polysaccharide towards different pollutants can be improved by the addition of fillers such as graphene and its derivatives. In particular, graphene oxide (GO) is well known as adsorbent for water purification [1,3] due to its large specific surface area, high hydrophilicity and numerous active adsorption sites with anionic properties.[1,3] Owing to electrostatic or π conjugate interactions, GO shows good affinity with many cationic or aromatic pollutants [3]. Although GO is able to self-assemble with CS in acid solution, CS/GO aerogels are relatively unstable and tend to dissolve even in weakly acid conditions [1]. To overcome this issue, robust CS-based hydrogels can be obtained by using two different approaches, namely the physical or chemical crosslinking [1].
Apart from the chemical features, the adsorption capacity of CS-based aerogels can be also optimized by controlling their porosity and surface area. Among the possible ways of producing CS aerogels, the freeze-drying of CS hydrogels is one of the most effective. The challenge is obtaining a material that is highly porous, but also mechanically stable in order to be handled and possibly regenerated and reused. [1]
In this work, CS/GO aerogels have been prepared with controlled porous morphology in order to tailor their adsorption properties towards several pollutants. Specifically, the aerogel performances have been tailored by tuning the CS/GO weight ratio, crosslinking strategy, and the freezing conditions. In particular, the prepared CS/GO dispersions have been frozen following two different protocols: 1) isotropic freezing method in which the CS/GO dispersion has been poured in stamps and kept in a freezer at -20°C; 2) bi-directional freezing method where the CS/GO dispersion is immersed in liquid nitrogen. CS/GO aerogels obtained by the first freezing protocols are characterized by cellular structures exhibiting pore size ranging from several tens to hundreds of microns, while nanocomposite aerogels obtained by the second protocols show lamellar structures with channels oriented in the direction of ice growth. For the crosslinking of the aerogels, two procedures have been investigated. In detail, glutaraldehyde, as crosslinking agent, has been added to the CS/GO dispersion in different ratios. Then, the samples have been frozen i) before or ii) after that the crosslinking reaction has taken place. In the second case, after the freeze-drying, the aerogels were subjected to a thermal treatment at 90°C to allow the occurring of crosslinking reactions.
The resulting nanocomposite CS/GO aerogels have been tested as materials for both water and air purification. In details, the adsorption properties towards anionic and cationic dyes, such as indigo carmine (anionic) and methylene blue (cationic), and towards VOCs, such as acetic acid, formic acid, formaldehyde and toluene have been investigated. The obtained results indicate that the developed nanocomposite CS/GO aerogels are promising candidates for environmental clean-up.

References:
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