Fabrication and Mechanical Stabilization of GNP-based Aerogels

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Graphene aerogels (GA) are very useful materials for those technological applications where high-surface development and good electrical conduction characteristics are required [1]. Such nanostructured materials can be prepared by drying a high concentrated graphene colloid, however poor mechanical stability is typically achieved. In order to provide better mechanical resistance to this material, GA can be cross-linked by pure elementar sulphur (heating the sulphur/GA blend at 180°C). In particular, graphene is a very good substrate for chemical functionalization by radical addition reactions, since its reactivity is comparable with that of other polycyclic aromatic hydrocarbons. The presence of carbon-carbon double bonds (C=C) makes this material as adequate substrate for radical addition reactions. For example, sulphur molecules (S_8) decompose at liquid state producing linear bi-radicals c-S_8→•l-S_8• (λ-transition) [2], which are able to graft the graphene-based framework of the aerogel, thus cross-liking it. Such a chemical process significantly improves the material mechanical stability (see Figure 1).

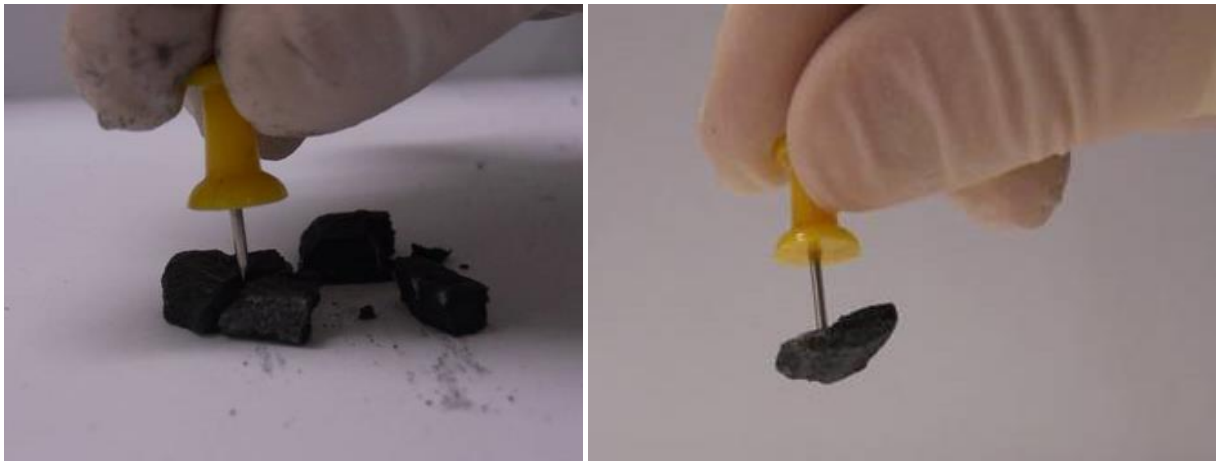

Figure 1. GA sample before (a) and after (b) the cross-linking treatment by elemental sulphur.

Scanning electron microscopy (SEM) images of the graphene-sulphur system (after this cross-linking process) showed the presence of the sulphur molecules at the edges of neighbors GNP unities. X-ray energy dispersive spectroscopic (EDS) mapping was carried out to verify the composition of such materials (see Figure 2). Furthermore, differential scanning calorimetry (DSC) was used to study the kinetic behavior of such cross-linking treatment, in fact the complete sulphur-carbon network formation was evidenced by the progressive disappearance of the λ-transition signal of the pure sulphur phase. The amount of residual sulphur in the chemically modified material was evaluated by thermo-gravimetric analysis (TGA) and it corresponded to ca. 30% by weight. Further

approaches used to investigate the morphology and the structure of prepared graphene aerogels were: large angle X-ray powder diffraction, X-ray fluorescence spectroscopy, and infra-red spectroscopy.

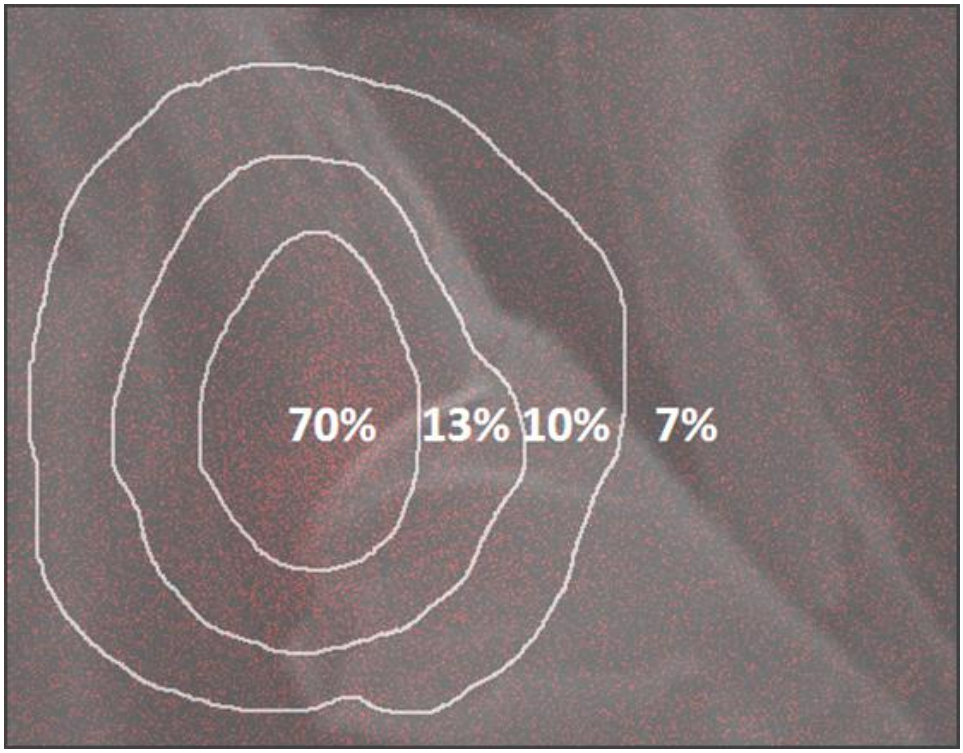

Figure 2. EDS-mapping of graphene-sulfur composite with the percentage values of S at the edges of the GNP units.

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References

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[2] Eichinger, BE., Wimmer E., et al., "The structure of amorphous sulfur", *Macromol. Symp.*, 171(2001)45-56.

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