Functionalization of RGO sheets with Polysulfone brushes to design nanocomposites

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Polysulfones (PSUs) are high-temperature thermoplastic polymers that exhibit great chemical inertness, enhanced oxidative resistence, thermal and hydrolytic stability, as well as high mechanical strength. Additionally, PSUs might be easily processed as a film and thus, they are good candidates for different applications, such as gas separation, hemodialysis, nano/ultra-filtration, adhesives for metal to metal bonds, membranes for fuel cells, drug delivery, or matrices for fiber reinforced composites.[1,2]

Polymer-matrix nanocomposites formed by incorporation of graphene sheets in polymer matrices have attracted enormous attention in various fields of science and engineering, due to the excellent properties of graphene sheets. In recent years, graphene-based polymer nanocomposites have been used to improve the mechanical, thermal, electrical and gas barrier properties of polymers and have shown great potential for diverse applications in electronics, aerospace, automotive manufacturing and green energy.[3,4,5]

In this work, we report a comparative study of the mechanical and electrical properties of different nanocomposites based on reduced graphene oxide sheets (RGO) covalently modified with PSU or without surface modification, in every case dispersed in a PSU matrix. GO was synthesized using Brodie method[6] and then thermally reduced under a hydrogen atmosphere. RGO surface was modified by two different chemical routes[7,8] (Figure 1) to improve its interfacial compatibility with the PSU matrix. Both synthesis methods allowed anchoring polymer chains to RGO sheets. By controlling the anchor point of the PSU to the RGO (Route 1 or 2, Figure 1) it was possible to obtain composites wherein the polymer was bonded at the end or in the middle of the chain (RGO-PSU-ext and RGO-PSU-mid, respectively).

The resulting RGO-PSU nanocomposites were carefully characterized by raman spectroscopy, infrared spectroscopy, differential scanning calorimetry, thermogravimetric analysis, and nuclear magnetic resonance, evidencing the successful anchoring of polymer onto the surface of RGO (Table 1). Furthermore, the modified RGO dispersions exhibit long-term stability in common solvents.

PSU nanocomposites were prepared with different percentages of PSU-RGO (up to 1%) by extrusion. The extruded material was further processed by injection molding to finally obtain specimens for mechanical and electrical tests.

The morphology and microstructure of the prepared samples were examined with a scanning electron microscopy (SEM). The mechanical strength was evaluated using a Shimadzu Autograph testing machine with a 1KN load cell. Furthermore, samples were analyzed by dynamic mechanical thermal analysis (DMTA) and differential scanning calorimetry (DSC), and the electrical conductivity was determined using a HP34401 device.

In this work, modified graphene with polysulfone was successfully obtained by nitrene chemistry. Moreover, the surface modification of RGO has ended up being a great strategy for enhancing its dispersion in the PSU matrix. The results indicate that the extrusion-injection procedure enables to efficiently prepare PSU-RGO nanocomposites with good dispersion degrees of RGO in the matrix. The enhancement of mechanical and electrical properties was interpreted in terms of the dispersion and interface modification of RGO.

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Table 1: Characterization of modified RGO by TGA and Raman Spectroscopy

Sample	TGA			Raman		
	Weight loss (%)	Polymer chains per 1000 carbon atoms	Polymer chains per μm^{-2} ($\cdot 10^{-4}$)	Raman shift (cm^{-1})		I_D/I_G
				I_D	I_G	
RGO	18.3	--	--	1367	1594	0.802
RGO-PSU ext	32.0	1.3	2.5	1381	1580	0.629
RGO-PSU mid	29.1	1.2	2.3	1375	1589	0.740
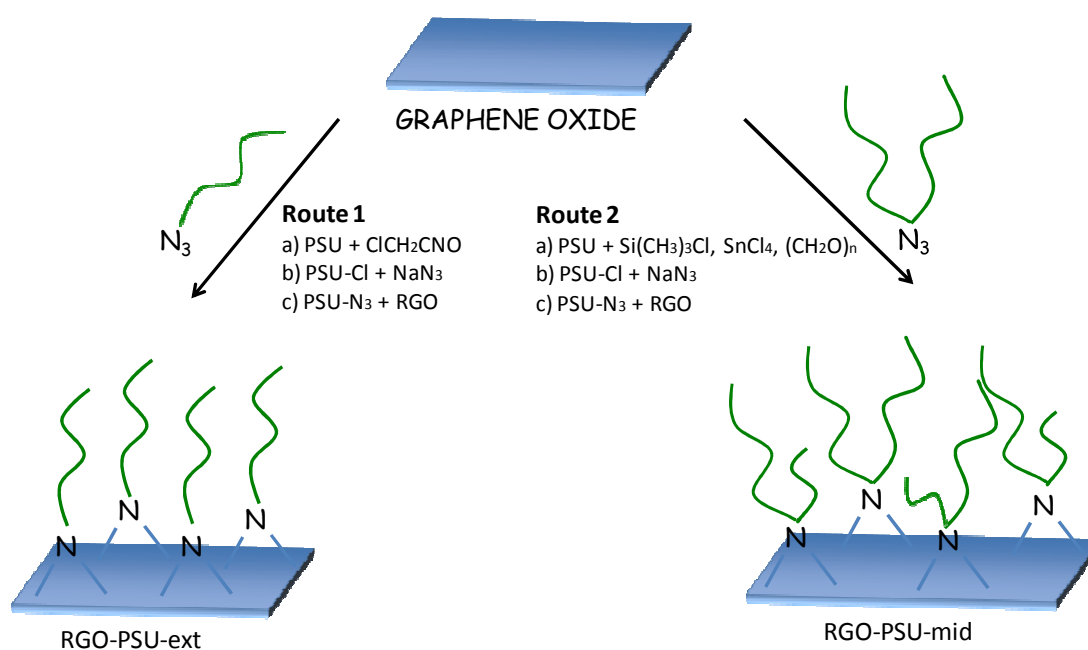
Figure 1: Scheme of the different grafted PSU onto the RGO surface