Advanced characterization of new inorganic-organic nano hybrids based on silica and polyacrylic acid

National Research & Development Institute for Chemistry & Petrochemistry ICECHIM Bucharest

Anita-Laura Ciripoiu[1] (raduanita@yahoo.com), Andrei Sarbu[1], Anamaria Lungu[1], Celina Damian[2]

[1] National Research and Development Institute for Chemistry and Petrochemistry-ICECHIM, Romania

[2] The Faculty of Applied Chemistry and Material Science, University POLITEHNICA of Bucharest, Romania

ABSTRACT

The hybrid composites consisting of nano-inorganic particles and polymers have received considerable attention due to the fact that resultant materials are supposed to have better mechanical or thermal properties. The hybrids may exhibit novel and excellent properties and may be promising in many applications such as catalyst and porous supports, advanced ceramics, etc.

The present work reports a study on the radical polymerization of an acrylic monomer in the pores of the mesoporous silica. New polymer inorganic-organic nanocomposites based on polyacrylic acid were synthesized. The main purpose was to investigate new possibilities to obtain novel hybrid composites with enhanced properties. The obtained composites were characterized by spectroscopic methods (FTIR, XPS) and thermal analysis (TGA, DSC).

RESULTS

The chemical composition of the nano hybrids are given in Table 1. The FTIR results (Fig. 1 and Table 2) of the new silica-poly(acrylic acid) inorganic-organic composites, with different organic content, shows the characteristic bands of the silica and polymer. The XPS analysis (Fig. 2, Table 3) was useful to point out the hybrid obtaining. Thus it was noticed an increased percentage of silicium with the increase in monomer content. The oxygen and carbon quantity has a complex variation with the introduction in system of oxygen from the organic acid. The polymer amount existing in the hybrids after the polymerization process was determined from TGA (Fig. 3) and the degradation stages from DTG (Fig. 4). The weight loss for the composites (47.45%, 56.33%, 66.4%) increases because of the organic fraction existence in the inorganic pores. The hybrid thermostability is increased with the increase of polymer concentration from the mixture. DSC curves (Fig. 5) showed exothermic effects for the composites, with the maximum at about 145 °C, assigned to some cyclization processes of the polymer, and a second one at 280 °C, attributed to crosslinking processes of polyacrylic acid.

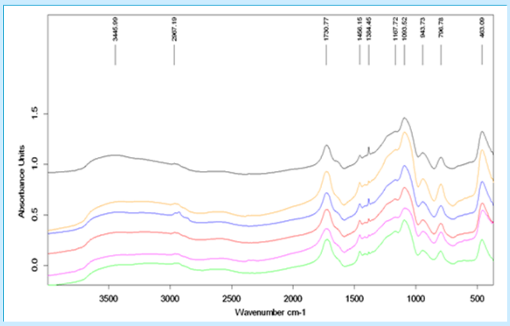


Fig. 1: FTIR spectrum of P1c, P2c, P3c, P4c, P5c, P6c silica-PAA silica nanocomposites

Table 2: The spectral assignments of the obtained nano hybrids

Wave number (cm^{-1})	Spectral assignments
3445.99	ν_{Si-OH}
2967.19	ν_{C-H} as from CH_3
1730.77	$\nu_{C=O}$
1456.15	δ_{C-O-H}
1167.72	ν_{COO-}
1093.52	$\nu_{Si-O-Si}$ as from optical-transversal component
943.73	δ_{OH} from octahedral unity of (AlOHAl)
796.78	δ_{O} Si-O-Si
463.09	Bending vibrations of Si-O-Si bond

Table 1: The composition of the samples used for nanocomposites obtaining

Sample	Silica (g)	Acrylic acid (mL)	wt/vol ratio
P1 c	2	4.5	1:2.25
P2 c	2	4.8	1:2.4
P3 c	2	5	1:2.5
P4 c	2	5.2	1:2.6
P5 c	2	5.5	1:2.75
P6 c	2	5.8	1:2.9

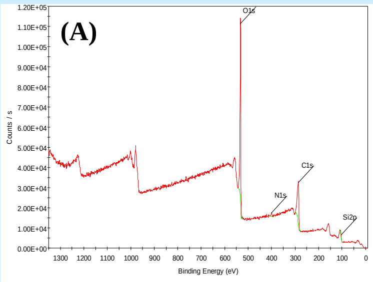
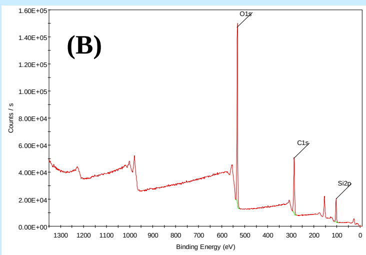
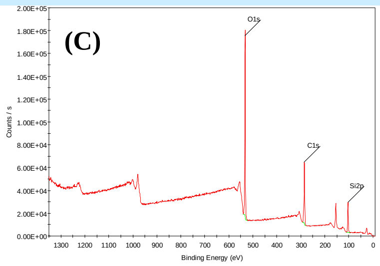


Fig. 2: XPS survey spectra for (A) P1c, (B) P3c and (C) P6c silica-PAA composites





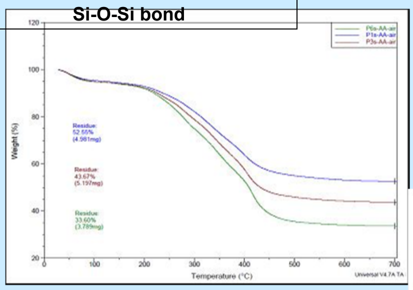
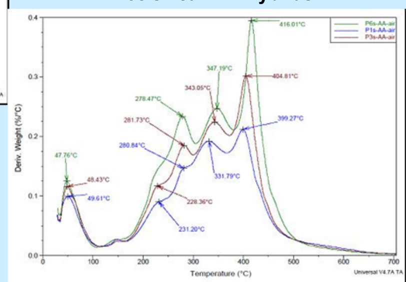
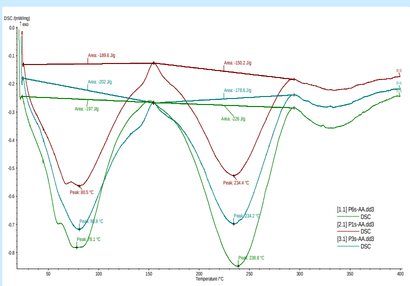


Fig. 3: TGA analysis for P1c, P3c, P6c silica-PAA hybrids

Fig. 4: DTG courbes for P1c, P3c, P6c silica-PAA hybrids





Sample	Si 2p, %	O 1s, %	C 1s, %
P1c	13.78	44.41	40.71
P3c	12.56	48.21	39.23
P6c	11.85	49.19	38.95

Table 3: The chemical composition of the obtained nano hybrids

Fig. 5: DSC courves for silica-PAA composites