

ORIGINAL PAPER

**Bi-hybrid coatings: polyaniline–montmorillonite filler
in organic–inorganic polymer matrix**

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Received 13 July 2012; Revised 26 October 2012; Accepted 29 October 2012

A bi-hybrid composite is represented by an organic–inorganic (O–I) filler dispersed in an O–I matrix. Polyaniline–montmorillonite, as a nanocomposite filler, was synthesised by two independent processes: (1) montmorillonite was surface-modified with a conducting polymer, polyaniline, during the in-situ oxidation of aniline or (2) montmorillonite was pre-treated with aniline, then the aniline was polymerised and the polyaniline subsequently produced penetrated the montmorillonite structure. The organic–inorganic polymer matrix was formed in two independent steps: (1) inorganic building units were formed in situ by the sol–gel process, (2) followed by organic polymeric matrix formation by polyaddition reactions of epoxy groups with amines. Polyaniline–montmorillonite filler was added to the reaction system between these two steps, i.e. when the inorganic structures of the O–I matrix have already been formed but prior to formation of the organic polymeric matrix. Two different O–I matrices were prepared from functionalised organosilicon precursors and oligomeric amines. 3-[(Glycidyloxy)propyl]trimethoxysilane reacted with α,ω -oligo(propylene oxide) diamine and diethoxy[3-(glycidyloxy)propyl]-methylsilane reacted with α,ω -oligo(propylene oxide) triamine. The resulting bi-hybrid coatings, the O–I filler dispersed in the O–I matrix, were characterised by atomic-force and optical microscopies, and also by tensile tests. The filler composition affected both the mechanical and surface properties of the coatings.

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Keywords: polyaniline, montmorillonite, organic–inorganic composite, hybrid coatings, microscopy, tensile properties**Introduction**

In the last decade, there has been increased interest in hybrid organic–inorganic materials and the coatings have become especially popular (Ruiz-Hitzky & Aranda, 1997; Sanchez et al., 1999; Han et al., 2009; Chisholm et al., 2010; Špírková et al., 2008a, 2010, 2011; Omastová & Mičušik, 2012). These materials have unique properties which are not obtainable by organic or inorganic components alone. The important method for the preparation of inorganic building units in hybrid materials is the sol–gel process, which makes it possible to control the structure of a material on a nanometre scale from the earliest stages of preparation (Hench & West, 1990; Špírková et al., 2003, 2008a; Belleville, 2010). The potential application of

these materials covers fields such as abrasion, corrosion protection, hydrolytic, and oxygen-barrier coatings (Mosher et al., 2006; Triantafyllidis et al., 2006), etc.

Inorganic additives and fillers, such as montmorillonite (MMT) and colloidal silica, influence the surface morphology and mechanical properties of coatings (Špírková et al., 2004, 2008a, 2008b). The coatings may also contain fillers of an O–I nature. In this paper, we report on the preparation of bi-hybrid coatings composed of such an organic–inorganic filler, polyaniline–montmorillonite (Wu et al., 2000; do Nascimento et al., 2004; Bober et al., 2010; Kazim et al., 2012), in the O–I polymer matrix.

Polyaniline (PANI) is probably the most extensively studied conducting polymer, due to its easy

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