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Novel chiral poly(amide-imide)/surface modified SiO_2 nanocomposites based on *N*-trimellitylimido-L-methionine: Synthesis and a morphological study

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ABSTRACT

In the present investigation, novel poly(amide-imide) (PAI)/SiO_2 nanocomposites (NCs) containing L-methionine moiety in the main chain were prepared via a simple and fast ultrasonic irradiation process. PAI was synthesized by direct poly condensation reaction of *N*-trimellitylimido-L-methionine with 4,4′-diamino diphenylether in molten tetra-n-butyl ammonium bromide/triphenyl phosphite as a green condensing agent. Due to the high surface energy and tendency for agglomeration, the surface of SiO_2 NPs was modified with chiral diacid. The obtained NCs were characterized by Fourier transform-infrared (FT-IR) spectroscopy, thermogravimetry analysis, X-ray powder diffraction, field emission-scanning electron microscopy (FE-SEM), and transmission electron microscopy (TEM). The FT-IR spectroscopy indicated that the chiral diacid as the coupling agent was attached on the surface of SiO_2 NPs. FE-SEM, and TEM images showed that SiO_2 NPs were dispersed rather homogeneously in the PAI matrix.

1. Introduction

Nanocomposites (NCs) are organic–inorganic hybrid materials in nano-scale which result from the assembly of organic and inorganic components, typically a polymer as the organic matrix and a nanoparticle (NP) as the inorganic solid. In recent years, NCs have become a rapidly growing field of research due to their different applications in biotechnology, biomedicine, optics, biochemical sensor design, tissue engineering and drug delivery systems [1–4]. NC materials have attracted enormous interest from researchers to mix nano-scale inorganic fillers with organic polymers. They possess interesting thermal, electrical, optical, magnetic, and mechanical properties, usually superior to those of the parent polymer or inorganic species [5–7]. The ratio between the metal oxide and the pure polymer in the composite controls the properties of these NCs [8,9]. Among the inorganic fillers, amorphous nanosilica particles (NSPs) have a special place because of good stability, high refractive index and its significant potential application in photo-catalysts [10,11]. NSP plays an important role in nature, science and technical applications due to its special physical and chemical properties [12–15]. NSPs have many such applications as in chemical sensors, polishing materials, catalysts, thin film photovoltaic solar cells, piezoelectric, luminescent devices, food industries and cosmetic materials [16–21]. NSPs are easy to aggregate and difficult to disperse in the polymer matrix because of their high specific surface area and surface energy, so it is necessary to modify their surface prior to use.

Surface modification of nano-SiO_2 with chiral diacid (DA) is one of the efficient ways to improve the surface properties, because the functional groups of chiral DA onto the surface of NPs prevent aggregation and extraordinarily increase the affinity of the NSPs surface with the polymer matrix [22,23].

Polymer matrix should usually have several properties such as chemical stability, biocompatibility and chemical functionalities [24]. Chiral poly(amide-imide)s (PAIs) can be a good candidate for these purposes, because of their significant properties such as high thermal stability, mechanical strength, good chemical resistance, high biodegradability and flexibility [25–27]. In addition, incorporating α-amino acids into their backbones help them to have chiral property and increase the

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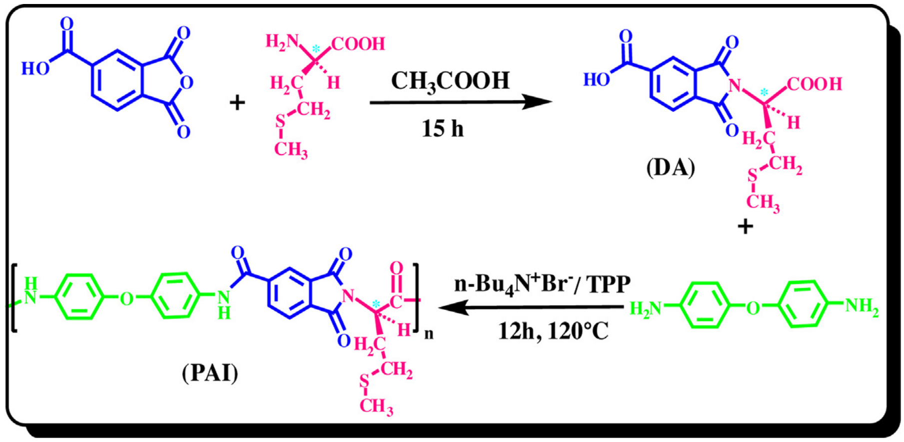


Scheme 1. Synthesis of DA and PAI.

biodegradability properties of these polymers. L-methionine is a common structure of natural amino acid that is used in the structure of proteins. This α-amino acid has an aliphatic chain which increases the flexibility in the macromolecule chains [28–30].

In the present investigation, novel optically active PAI/SiO_2 NCs containing L-methionine moiety in the main chain were prepared using ultrasonic irradiation. For this aim, in order to prevent agglomeration of NPs and also the stronger interactions between filler and PAI matrix, the surface of SiO_2 NPs was modified using biocompatible and optically active DA as a coupling agent; then different percentages of modified fillers were incorporated in the PAI matrix. The resulting novel NCs were characterized by a number of techniques.

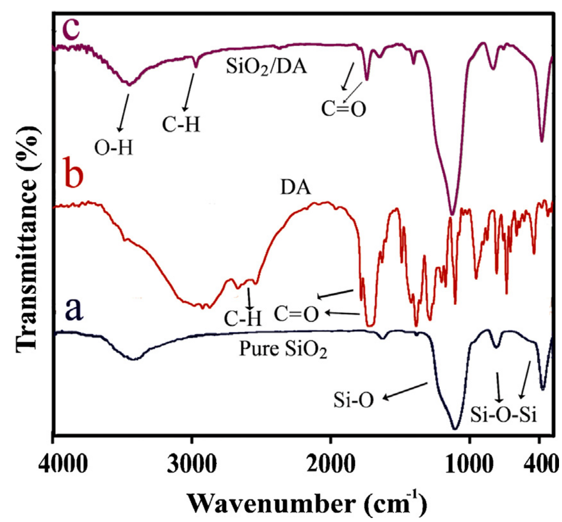
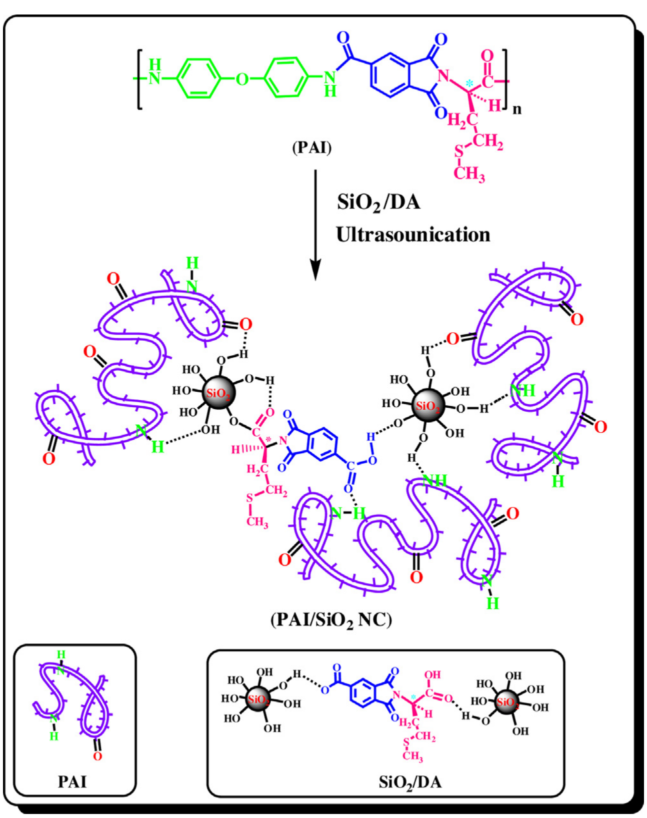


Fig. 1. FT-IR spectra of the SiO_2 NPs (a), DA (b) and modified SiO_2 (c).



Scheme 2. Preparation of PAI/SiO_2 NCs.

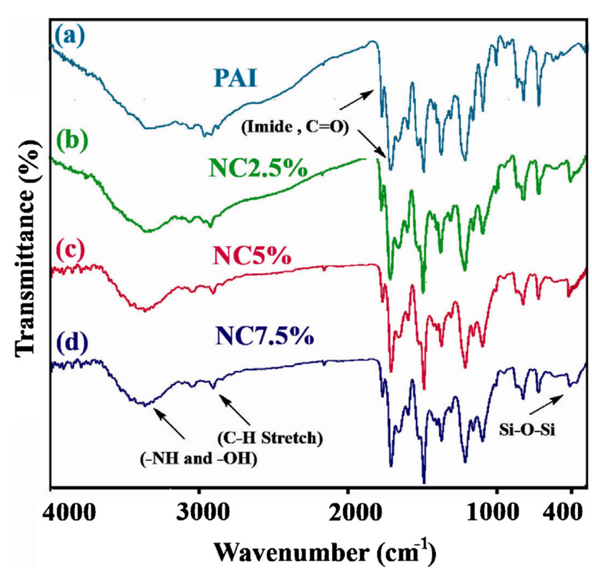


Fig. 2. FT-IR spectra of pure PAI (a), PAI/SiO_2 2.5% (b), PAI/SiO_2 5% (c) and PAI/SiO_2 7.5% (d).