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Nano-Chemical Engineering and Nano-Processes in Manufacturing Multi-functional Nanocomposites

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Abstract

Nano-Chemical engineering and nano-processes are critical in manufacturing multifunctional nanocomposites which are used for wide applications. Innovations made in nano-chemical engineering and nano-processes have enhanced performances of existing nanocomposites and developed new types of nanocomposites. On the other hand, the nano-chemical engineering and nano-processes can be affected by the design of the nanocomposites.

Key words: Nano-chemical engineering; Nano-process; Nanocomposites

Nano-Chemical engineering and nano-processes essentially deal with the technology of large-scale chemical production and the manufacturing of products through chemical processes employing nanotechnology [1,2]. Nano-Chemical engineering and nano-processes play a key role in fabricating multifunctional nanocomposites which are defined as "two or more materials with different properties remain separate and distinct on a macroscopic level within one unity and with any dimension in any phase less than 100 nm"[3-5]. The produced nanocomposites are essential for technological progress and have demonstrated versatile applications ranging from environmental remediation, energy storage, electromagnetic (EM) absorption, sensing and actuation, transportation and safety, defense system, information industry, to novel catalysts, etc., Figure 1. [3-14]

The nano-chemical engineering and nano-processes to manufacture nanocomposites differ depending on the types as well as the applications of the nanocomposites. For example, electrochemical polymerization techniques are usually utilized to obtain conductive polymer nano thin films for

Figure 1: Nannocomposites fabricated via nano-chemical engineering and nano-processes for versatile applications. Reproduced from (Ref 10) with permission of The Royal Society of Chemistry.

electrochromic devices [15,16] or anticorrosion coatings to protect metal substrates,[17] whereas chemical oxidative polymerization techniques are preferred to achieve power-form nanocomposites for electrochemical energy storage [18,19] or giant magnetoresistance sensor applications.[20]

Progresses made in nano-chemical and nano-process often bring innovative products or improved performances which can meet ever increasing requirements of materials and broaden their applications. A typical example has been witnessed in the electrospinning technique for fabricating polymer nanofibers. Only single-structured nanofibers can be obtained using conventional electrospinning setup, Figure 2 a&b. Fortunately, core–sheath fibers with more attractive merits including controllable mechanical strength, and better thermal and electrical conductivities can be produced using an innovative extension of co-axial electrospinning setup, Figure 2c.[21-25]

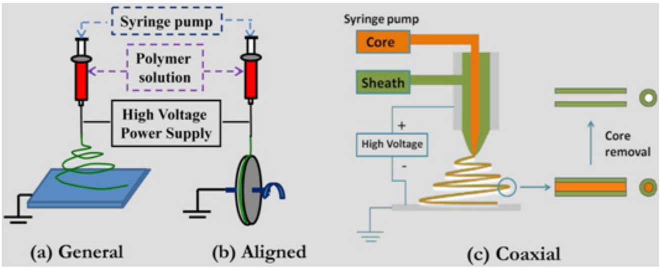

Figure 2: Electrospinning setup for conventional (a & b) and co-axial (c) to fabricate polymer nanofibers. The fibers (green color in a & b and yellow color in c) are produced from polymer solutions (red color in a & b and light green and light yellow in c) in the syringe. Reproduced from (Ref 21) with permission of The Royal Society of Chemistry.

Another example has been illustrated by the synthesis of magnetic polyurethane nanocomposites with high loading of Fe_2O_3 nanoparticles. Brittle and cracked nanocomposites with larger clusters with agglomerated nanoparticles wrapped with a continuous polymer matrix were produced using conventional direct mixing (DM) method, Figure 3a.[26] In contrast, flexible nanocoomposites with uniformly distributed nanoparticles were obtained using surface-initiated-polymerization (SIP) method, Figure 3b. The elongation of the SIP nanocomposite is about four times greater than that of the DM composite in the tensile test, which renders possible coating industrial applications in the areas of electromagnetic wave absorbers and communication systems for the former.

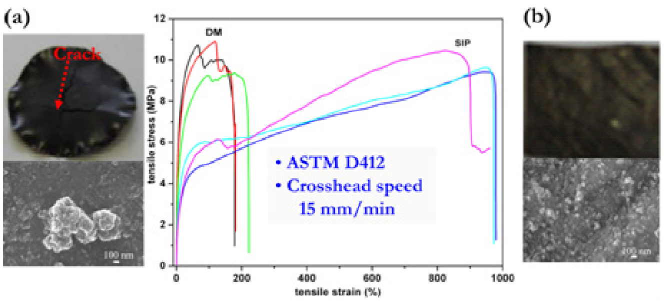

Figure 3: Magnetic Fe_2O_3/polyurethane nanocomposites obtained by DM (a) and SIP (b) method, respectively. The loading for Fe_2O_3 nanoparticles is 65 wt%. Reproduced from (Ref 26) with permission of IOP Publishing Ltd.

On the other hand, the nano-chemical engineering and nano-processes can be affected by the design and engineered nanocomposites. By adding iron into the epoxy matrix, a lower curing temperature was obtained indicated by differential scanning calorimetry (DSC) study, as illustrated in Figure 4.[27]

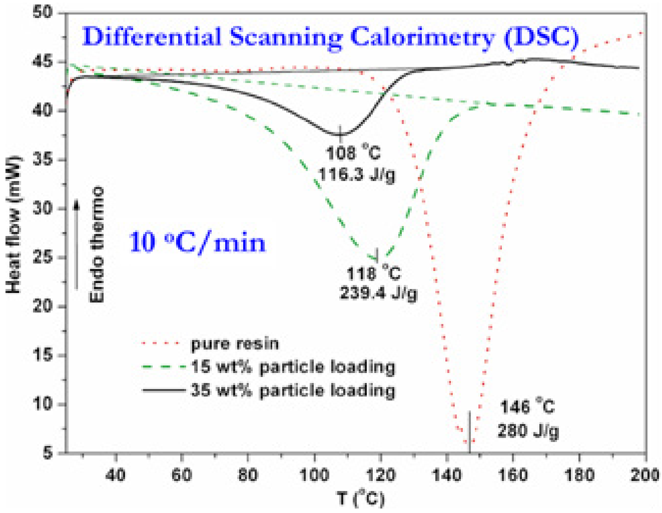

Figure 4: Nanofiller effect on the curing process of the nanocomposite. Reproduced from (Ref 27) with permission of Elsevier Ltd.

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