

Solubility and swelling studies of polymer hybrid-nickel oxide nanocomposite

A. Suhasini^a and K. P. Vinod Kumar^{b*}

^aDepartment of Chemistry, St. Xavier's Catholic College of Engineering, Nagercoil-629 003, Tamilnadu, India

^bDepartment of Chemistry, University College of Engineering, Nagercoil-629 004, Tamilnadu, India

E-mail: nanjilvino@rediffmail.com

Manuscript received online 27 August 2018, accepted 09 October 2018

Polymer nanocomposites involve a very important class of organic-inorganic nanostructured material which has enormous applications in storage, conversion devices. A polymer blend is prepared with polyurethane diol and polycaprolactone with the ratio of 4:1. Nickel oxide nanoparticle of various proportions was added to the polymer blend to obtain a complete polymer nanocomposite. The present work focuses the solubility and swelling studies of polymer nanocomposites prepared.

Keywords: Polycaprolactone, polyurethane diol, nickel oxide nanoparticle, swelling, solubility.

Introduction

Polymer blending is one of the inexpensive and simple techniques to prepare new polymeric materials which are different from individual polymeric component. When compared to pure polymers, polymer blending shows superior conductivity and high mechanical strength¹. Among the commercialized biodegradable polymers, polycaprolactone (PCL) is superior because of its high flexibility, biodegradability and hydrophobic nature². Polyurethane diol (PUD) is one such type of polyurethanes, which is biodegradable and synthetic³ polymers. Nickel oxide nanoparticle is an attractive material due to its valuable electronic and magnetic properties. These materials are useful in catalysis, fuel cell electrodes, gas sensors, and in lithium-ion batteries⁴.

Experimental

Materials:

Polycaprolactone, polyurethanediol, 4,4'-diaminodiphenylmethane, hexamethylene diisocyanate, nickel oxide nanoparticles, dimethyl formamide, dimethyl sulphoxide, ethyl methyl ketone, ethanol, diethyl ether, ethyl acetate, hydrochloric acid and sodium hydroxide (Merck).

Synthesis of PUD/PCL-NiO nanocomposites:

Polyurethane diol (40 g) was heated up at 90°C and subsequently 10 g of polycaprolactone was added. The blend was heated at 120°C and stirred for 30 min. To this blend,

0.5 g of NiO nanomaterial was added gradually and vigilantly with the mixture and stirred at 415 rpm for 45 min. Then heating was discontinued and 12 ml hexamethylene diisocyanate and 4 g diaminodiphenylmethane were supplemented and swirled. The organized nanocomposites were relocated in to the mold and dried. The same procedure be followed for NiO nanoparticle of various concentrations such as 1.0, 1.5, 2.0, 2.5 wt% composites.

Solubility of PUD/PCL-NiO nanocomposites:

The solubility studies revealed that the blend and the nano-composites prepared were completely soluble in dimethyl sulphoxide, dimethyl formamide and ethyl methyl ketone. This is because of the above solvents and prepared materials show high polarity interaction between them. But the prepared materials are moderately soluble in solvents such as diethyl ether, ethanol and ethyl acetate.

Water swelling:

Water swelling analysis was carried out by ASTM D570 standard at room temperature in distilled water for 25 days by immersing the material. The gain of weight by the sample at a time t , can be determined by the given equation as,

$$M_t = ((W_w - W_d)/W_d) \times 100 \quad (1)$$

where W_d and W_w represents dry weight of material and swelled material weight at a period of time, t respectively.

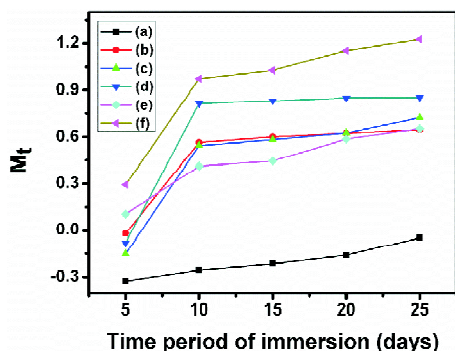


Fig. 1. Water swelling of PUD/PCL-NiO nanocomposites.

This is because the blend and nanocomposites are composed of polymers by high electronegative atoms and hence the dipolar groups from water favouring the interaction between water and the synthesized materials prevail and hence water swelling takes place. Further 2.5 wt% loaded nanocomposite shows better water swelling than other nanocomposites prepared, this is because that the increased NiO prohibited the movement of the polymer segments, which should provide free space for the water molecules to stay in the composites. In the backbone structure of the blend and composites, there are an attribution of hydrophilic functional groups and free volume like hydroxyl groups, involve in the absorption of moisture⁵. Moreover NiO nanoparticles are polar in nature, which will help to bind better with the water molecules in the composites.

Solvent swelling:

Solvent swelling was done for the blend and nanocomposites by immersing the materials in particular solvents for 25 days by periodical weighing after elimination of the surplus solvent from the sample with filter paper. The same was repeated until equilibrium swelling was achieved. The solvent swelling 'q' can be calculated by the given equation⁶

$$q = (m - m_0)/m_0 \quad (2)$$

where, m_0 and m are the weight of sample before and after swelling, respectively.

On the other hand, the blend and the nanocomposites absorb the solvents such as HCl and NaOH. This is because through the electrostatic attraction, extraction of the sol fraction is caused in the synthesized material. The swelling of different solvents such as HCl and NaOH by the materials prepared is shown in the given plots Fig. 2 and Fig. 3.

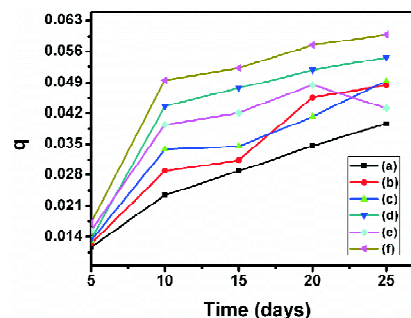


Fig. 2. Swelling of PUD/PCL-NiO nanocomposites in 1 N HCl.

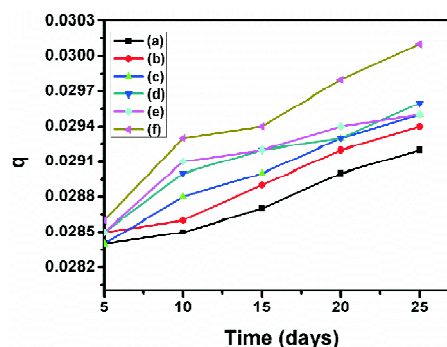


Fig. 3. Swelling of PUD/PCL-NiO nanocomposites in 1 N NaOH.

Conclusions

The nanocomposites prepared were absolutely soluble in solvents such as DMF, DMSO, and EMK. On the other it is partly soluble in solvents such as DEE, EA and ethanol. High electronegative atoms in polymers in nanocomposites support the polarity interaction between water and the prepared materials and thus water swelling takes place. In addition to this the blend and nanocomposites are absorbed by the solvents like HCl and NaOH through the electrostatic attraction.

References

1. S. Ramesh, T. Winie and A. K. Arof, *Eur. Polym. J.*, 2007, **43**, 1963.
2. A. Suhasini, KPV Kumar and T. Maiyalagan, *Sci. Eng. Compos. Mater.*, 2016, DOI: 10.1515/secm-2015-0531.
3. M. Ghosh, K. Biswas, A. Sundareshan and C. N. R. Rao, *J. Mater. Chem.*, 2006, **16**, 106.
4. Y. Ichianagi, N. Wakabayashi, J. Yamazaki, S. Yamada, Y. Kimishima, E. Komatsu and H. Tajima, *Physica B*, 2003, **329**, 862.
5. D. Yuan, C. Ju, S. Ding, X. Jing and C. Zhang, *J. Biomater. Sci.*, 2010, **21**, 493.
6. P. Czech, L. Okrasa, G. Boiteux, F. Mechin and J. Ulanski, *J. Non-Cryst. Solids*, 2005, **351**, 2735.