Using GO and clay to improve properties of PVA polymeric film

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Abstract: In this study, we have used a combination of MMT and graphene oxide in poly vinyl alcohol polymer matrix preparation. Graphene oxide was synthesized using modified Hummers method and then aqueous suspension of graphene oxide and montmorillonite were added to polymer matrix. According to characterization of polymeric film, we observed excellent results. Our study shows addition of small amount of graphene oxide with nanoclay significantly enhances properties of poly vinyl alcohol hybrid nanocomposite, too.

Keywords: PVA, GO, montmorillonite, polymeric film

Introduction

Polymer nanocomposites are generally defined as the combination of polymer matrix and filler that have two phase systems in order for the continuous phase in an organic polymeric matrix and dispersed inorganic particles of nanometer scale [1, 2]. The final properties of polymer nanocomposites depend strongly on the properties of the filler [3]. Nanoclays would be ideal systems due to their natural availability and low cost. Having high aspect ratio, large surface area, and good interfacial properties, layered silicate clay added to a polymer matrix can contribute to significant cost savings as a property enhancer. Clay-containing polymer nanocomposites may offer beneficial properties, such as good mechanical properties, dimensional stability, barrier properties, flame retardant, optical properties, and thermal stability [4-9] .

Graphene possessed many unique properties different than carbon materials, including a high specific surface, extraordinary electronic properties , high thermal conductivity $5\times 10^3 \mathrm{W}m^{-1}k^{-1}$, and the highest known intrintrinsic electrical conductivity of $6\times 10^5 \mathrm{S}m^{-1}$ [10, 11] .

Therefore, graphene oxide (GO) is the precursor for graphene and has been produced since the development of the Hummers method [12]. We used poly vinyl alcohol as polymeric matrix because of PVA is a water soluble and biodegradable polymer extensively used in many industrial applications. However the insufficient mechanical properties [14, 17].

In this study we tried to improve properties of PVA polymeric film by using graphene oxide nanoparticles. Thus the results show improvement in mechanical properties.

Experimental section

Sodium montmorillonite (MMT) clay with average particle size 13µm. Expanded graphite with average particle size 20µm. Sulfuric acid (H_2So_4) (%95-98), hydrochloric acid (HCl) (%37) and PVA powder. In this study we used a response surface methodology (RSM) for preparation samples. In this method, the design of experimental is done by defining the independent variables as inputs. Then perform number of tests to find the optimum relationship between one or more output variables. Also the experimental design in coded variables is shown in Table 1.

GO was synthesized using modified Hummers method [13]. MMT/PVA/GO nanocomposites we synthesized by solution-casting method.

PVA powder was added to deionized water and stirred. Then aqueous suspension of GO and MMT were added to homogeneous dispersion and stirred. Nanocomposite films with different MMT and GO loadings were prepared according to Table 1. Finally Resulting solution was cast into Petri dishes and dried in an oven, as it can be seen nanocomposites.

Table 1: Run conditions for experimental design

Run	Factor 1 A:graphene wt %	Factor 2 B:clay wt %
1	0.25	2.50
2	0.00	2.50
3	0.25	2.50
4	0.25	2.50
5	0.25	2.50
6	0.43	0.73
7	0.43	4.27
8	0.07	0.73
9	0.25	2.50
10	0.25	5.00
11	0.25	0.00
12	0.25	2.50
13	0.07	4.27

RESULTS AND DISCUSSION

Wide-angle X-ray scattering pattern of graphene oxide is shown in Figure2a. The sharp peak at $2\theta = 10°$ for GO indicates the effective oxidation of graphite resulting in an increased inter-layer distance between graphenic planes [14]. Small-angle X-ray scattering (SAXS) pattern of montmorillonite is shown in Figure2b with the distance $2\theta = 7$ to $9°$. According to the Bragg diffraction formula, the *d*-spacing is almost 1.10nm, which is consistent with the reported in the data sheets.

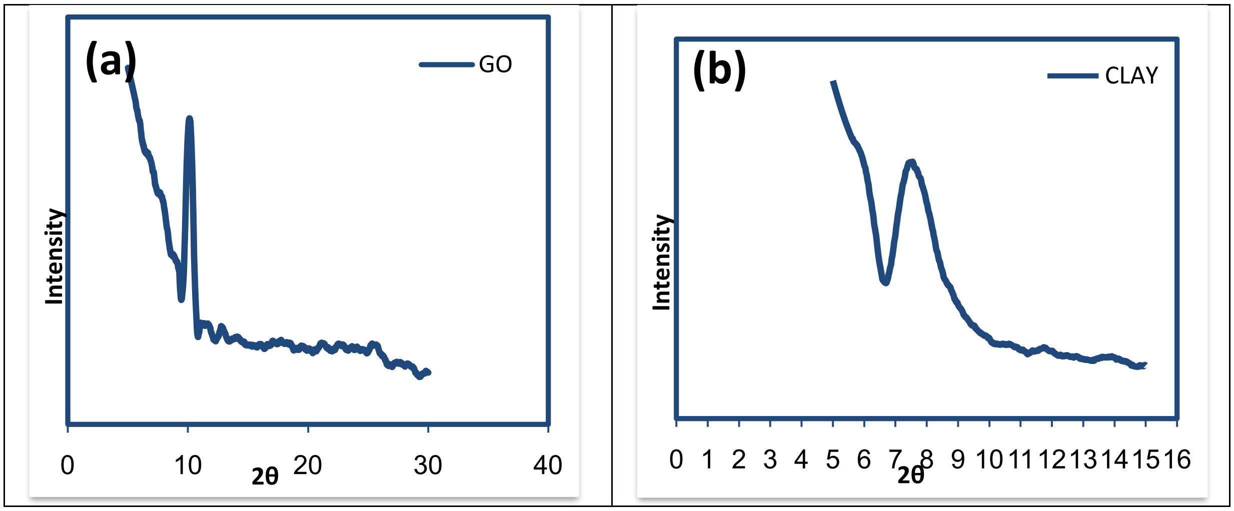

Figure 2: a) WAXD patterns of GO, b) SAXS patterns of clay

Figure 3 shows a scanning electron microscopy (SEM) image of the nanocomposites substrate include nanoparticles.

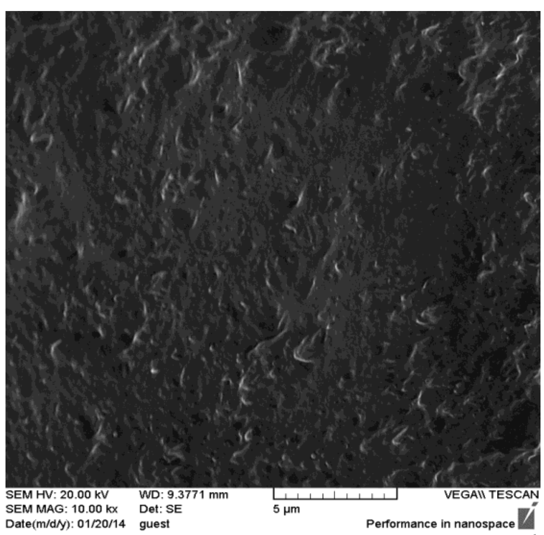

Figure 3: FE-SEM images of nanocomposites

There was a significant improvement in mechanical properties of the films. In this study, the response surface methodology (RSM) was used to design the experiment. As can be observed in the Figure 4, modulus increased with increasing concentration of nanoparticles, it is quite obvious that the modulus of the material increases when they were reinforced with fillers. Although the modulus decreased with decreasing concentration of nano fillers. Therefore, nanoparticles can act as physical cross-links and prevents slippage and elongation of the polymer chains.

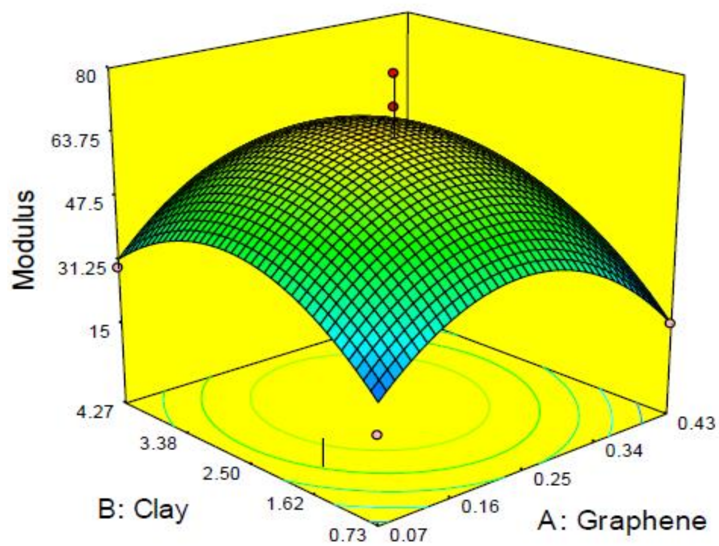

Figure 4: The curve of RSM

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