

# Thermal properties of poly(ethylene-oxide)/montmorillonite nanocomposites prepared using by sol-gel method

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**Abstract**— In this study, we studied the variation in the thermal properties of poly(ethylene-oxide)/montmorillonite nanocomposites containing clay at different ratios prepared by sol-gel method. Experimental results show that PEO/clay/silica hybrids display good thermal stability compared to pure PEO and the intercalation of polymer chains in montmorillonite galleries the crystallization of the poly(ethylene-oxide) matrix.

In the past decade, much research on the preparation of polymer/clay nanocomposites have been reported in the literature from both the academic and industrial communities, because some properties including mechanical properties (modulus, strength, thermal expansion coefficient) [1], barrier [2], flammability resistance [3], biodegradable stability [4] were improved relative to a virgin polymer. Different types of polymers have been used as matrix materials in order to fabricate polymer/clay nanocomposites with improved properties. Among these polymers, poly(ethylene-oxide) (PEO) has been a promising material since it has been used in so many different areas such as denture adhesives, packaging films, thickening of water-based paints, friction reduction, purification of biological materials, and pharmaceutical drugs. In addition to these applications, poly(ethylene-oxide) has been recognized as a potential solid polymer electrolyte (SPE) which can be used in rechargeable solid-state lithium-ion polymer batteries[5]. Poly(ethylene-oxide) has a suitable structure that can provide fast ion transport, and also it has the capability of dissolving so many different salts [6]. On the other hand, the most important disadvantage of PEO is its low ionic conductivity at room temperature due to the high concentration of its crystalline phase. For this reason, many different methods have been used in order to minimize the concentration of PEO crystalline phase while maintaining its flexibility and mechanical stability which extends over a wide Temperature range. One of the most effective methods has been the addition of inorganic filler materials such as clay or silica nanoparticles to PEO [5].

The inorganic clay, used in this study, was K-10 grade montmorillonite purchased from Sigma-Aldrich Co. (USA) with a surface area 220–270m<sup>2</sup>/g. The chemical composition (wt%) of the clay (main elements) was SiO<sub>2</sub>:67.6, Al<sub>2</sub>O<sub>3</sub>: 14.6, Fe<sub>2</sub>O<sub>3</sub>:2.9, MgO: 1.8 and others. Cation exchange capacity of the clay was 60meq/100g. Sol-gel nanocomposites (PEO/silica nanocomposites) are prepared by in situ acid catalysed hydrolysis and condensation of mononuclear precursors such as tetraethoxysilane (TEOS) in organic polymer matrices. This procedure was used to prepare the hybrids with TEOS/clay =20/3(w/w) and the varying ratios of PEO / MMT. A differential scanning calorimeter, Netzsch STA 409 PC Luxx apparatus, was used to study the thermal characteristics of the materials by recording the thermograms obtained at a heating rate of 5°C/min in a nitrogen atmosphere supplied at a flow rate of 60 cm<sup>3</sup>/min. The results are given in Table 1.

**Table 1.** The obtained results from the thermal analysis of poly(ethylene-oxide) and poly(ethylene-oxide)/clay-silica nanocomposite containing the various clay ratios(wt.%).

Sample	T <sub>m</sub> (°C)	ΔH <sub>m</sub> (J/g)	T <sub>1</sub> (°C)	T <sub>2</sub> (°C)	Mass loss(%)
PEO	65.2	101.65	355.7	424.5	99.93
0.5	60.2	94.67	359.4	411.6	86.47
1.0	62.5	97.34	330.0	401.7	98.71
2.0	59.6	111.48	361.6	415.2	91.90
5.0	62.1	103.02	231.6	383.9	88.12
10.0	62.4	80.96	333.0	398.9	72.73
15.0	60.3	80.90	341.8	419.6	63.05
20.0	61.1	138.62	270.8	384.8	60.34
25.0	35.0	99.00	209.8	348.6	42.77

From TG results, we found an increase in the thermal degradation temperature and thermal degradation rate with an increasing amount of clay. A small amount of MMT increases the residual weight of nanocomposites because of the restricted thermal motion of the polymer in the silica network. It can be obviously observed that the residual weight at high temperature increases with clay content. The introduction of clay enhances the performance by acting as a superior insulator and mass transport barrier to the volatile products generated during decomposition. Melting points of nanocomposites exhibit a decrease as the amount of MMT increases. This feature evidences that MMT filler hinders PEO crystallization, decreasing the proportion to crystalline polymer phase.

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