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Analysis of Structure of Natural Nano Clay during Clay/Polymer Nanocomposite Manufacturing Steps

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Abstract

Nanocomposite made of clay minerals and polyolefin goes through several stepst. During these steps materials will have changes especially in the structure and properties. Then the final material will be of both new structure and properties. These main steps in the manufacturing process will include the stages of preparation of the material components and mixing. The structures of the materials are well characterized at each step. Then, we can understand how the processing steps will affect the structures and mechanism for producing the final nanocomposite material. The results include characterization by SEM, TEM, XRD and EDAX chemical analysis. During the processing, the energy will be changed for both of the initial materials and the final product in addition to the materials properties which will depend on the energy changes. The analysis includes the methods of calculations of energy changes. Then, design suggestions are developed for energy control to produce nanocomposite with certain energy level to carry certain amount of loads. Therefore, the study will provide possibility for pre-control of the lifetime of the produced materials.

Keywords: Nanocomposite, Nano clay powder, Low density polyethylene LDPE particles, Inter-structure, Characterization and analysis, Manufacturing steps.

1. Introduction

The advanced functional material of clay-based nanocomposite is produced as a new type of material and science which needed new different treatment from other conventional materials or composites [1-10]. The previous studies [1-10] since founding and inventing of this type of nanocomposite have been conducted for processing new materials such as in situ polymerization, melt processing technique and sol-gel method [1-10]. The previous studies have been conduced for producing steps of mixing and characterization using SEM, TEM, XRD, ….etc, [1-10] for the micro structure of the final produced material. Some other investigators studied the properties of the final material [1-10]. The formation of the properties of the final material product and the morphology of the final structure depend mainly on the manufacturing steps. The structure and properties of the final nanocomposite will change in each step. (In addition to the quality, defects, cracks,….etc.) It also will depend on some other important factors other than the technique steps such as the time , temperature, experience of the designer and researcher and his background and knowledge on the fundamental analyses and mechanism, defects, interfacial bonds, distribution of the material, homogeneity, ….and so on. The quality of the product will depend on the observation and monitoring of the production steps. The quality will depend on the energy capacity of the product for keeping the absorbed energy which can be dissipated at certain level of applied loads. Therefore, the high energy level will permit the material to carry high amount of load without problems in addition to extending the lifetime of the produced nanocomposite. The analysis of the produced nanocomposite will be energy controlled. The design and analyses will depend on directional energy approach [11-15].

2. Experimental Procedure

The experimental work procedures for producing clay-based polymer nanocomposites have several main steps. These main steps include:

1- Preparation of the materials of nano clay powder and polymer material (LDPE).
2- Modifications and compatibility of the materials to be ready for processing.
3- Mixing of the main materials of clay and polymers. The mixing will include several processes.
4- Processing step which include several types such as:
    - In situ polymerization technique.
    - Melt processing technology.
    - Sol- Gel technique.

Each method is suitable for producing certain types of nanocomposites. In this research melt processing method is applied.

3. Analytical Procedure

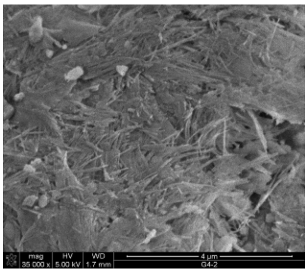
The analytical study of the materials included microscopy analysis by scanning and transmission electron microscopes (SEM and TEM) for studying the microstructure, nano structure and morphological aspects of the individual components materials and the admixture of the clay/polymer nanocomposite in different cases at each manufacturing step as shown in the Figures (1-4). X-ray diffraction (XRD) crystalline analysis is conducted as shown in Figure (4) while chemical analyses (EDAX) by electron beam is made as shown in Fig. (6). The surface area of the nano particle of clay is made since the surface area of the nano particles is one of the most important governing factor for producing the nanocomposite and the quality of the properties of the final product. The energy capacity of the final product of clay/polymer nanocomposite can be estimated. The detailed analysis of the energy and its components will be published in a separate paper soon.

4. Results and Discussion

Manufacturing process of Nanocomposite made of clay minerals and polyolefin goes through several steps to produce the final required product. During these steps and procedures, the nano material and material components will have changes in the shape, volume and structure. This is in addition to the changes in the properties. Then the final material will be of both new structure and new properties. These main steps in the manufacturing process will include the stages of preparation of the material components and mixing stages. Each of these two main step groups contains several procedures and sub steps. The structures of the materials are well characterized at each step. Then, we can understand how the processing steps will affect the structures and mechanism for producing the final nanocomposite material. The results include characterization by SEM, TEM, XRD and EDAX chemical analysis. During the processing, the energy will be changed for both of the initial materials and the final product in addition to the materials properties which will depend on the energy changes. The analysis includes the methods of calculations of energy changes. Then, design suggestions are developed for energy control to produce nanocomposite with certain energy level to carry certain amount of loads. Therefore, the research will provide possibility of lifetime pre-control for produced material.

Figure 1 shows the microstructure and nanostructure of the clay fibers showing the particle sizes and distribution while

Figure (2) and Figure (3) show the LDPE polymer particles and matrix respectively showing the morphology of LDPE as amorphous material. Figure (4) shows the clay/polymer nanocomposite admixture explaining the distribution and morphology of Clay 15% and LDPE 85% mix. The XRD analysis is shown in the Figure (5) for nano clay particles indicating that the nano clay is Montmorillonite clay which is smectite clay type. The chemical analysis by electrine beam EDAX is shown in Figure (6) indicating the elements of the nanocomposite which are Silicon Si, Aluminum Al, Magnesium Mg, carbon C, and Oxygen O. It is clear that the structure and morphology of the materials change clearly after each manufacturing step. The clay/LDPE nanocomposite changes depends on the factors of mix ratio, temperature, mix conditions, clay surface area, clay exfoliation, clay-polymer dispersions and intercalations, original particle sizes and conditions, time of processing and the original properties of the individual particles and matrix. The directional energy approach [11-15] is used for studying the mechanism and the energy analysis and calculations. The analysis includes the methods of calculations of energy changes. Then, design suggestions are developed for energy control to produce nanocomposite with certain energy level to carry certain amount of loads. Therefore, the research will provide possibility of lifetime pre-control for produced material.



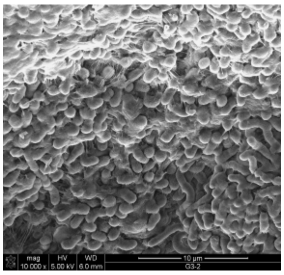
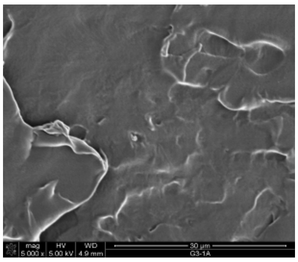


Fig. 1 agglomerated clay powder.   Fig. 2 LDPE particles



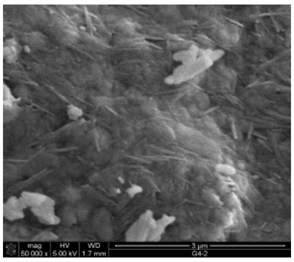
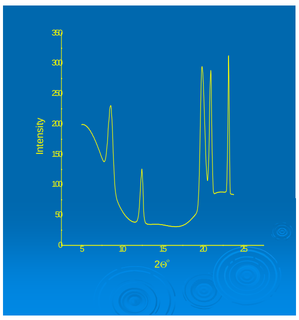


Fig. 3 LDPE melted particles. Fig. 4 clay/LDPE nanocomposite



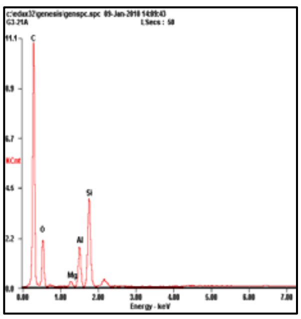


Fig. 5 XRD for clay/LDPE   Fig. 6 EDAX for clay/LDPE

4. Conclusions

As shown from the research, the manufacturing process of Nanocomposite made of clay minerals and polyolefin goes through several steps to produce the final required product. During these steps and procedures, the nano material and material components will have changes in the shape, volume and structure. This is in addition to the changes in the properties. Then the final material will be of both new structure and new properties. These main steps in the manufacturing process will include the stages of preparation of the material components and mixing stages. Each of these two main step groups contains several procedures and sub steps. The structures of the materials are well characterized at each step. Then, we can understand how the processing steps will affect the structures and mechanism for producing the final nanocomposite material. The results include characterization by SEM, TEM, XRD and EDAX chemical analysis. During the processing, the energy will be changed for both of the initial materials and the final product in addition to the materials properties which will depend on the energy changes. The analysis includes the methods of calculations of energy changes. Then, design suggestions are developed for energy control to produce nanocomposite with certain energy level to carry certain amount of loads. Therefore, the research will provide possibility of lifetime pre-control for produced material.

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References

1. Lili Cui, et. al, " Effect of organoclays purity and degradation on nanocomposite performance, part 2: Morphology and properties of nanocomposites, Texas material institute, USA, 2008.
2. P. C. Lebaron, Z. W., T. J. Pinnavila, "polymer – layered silicate nanocomposites: an overview", Center of Fundamental materials Research and composite materials and structure center, Michigan state Univ., USA, 1999.
3. D. H. kim, et. al, " Structure and properties of Polyproplyne-based nanocomposites: Effect of PP-g-MA to organoclay ratio", Texas material Institute, USA, 2007.
4. J. H. Lee, et. al, " Properties of polyethylene –layered silicate nanocomposites prepared by melt interaction with a PP-g-NA compatibilizer", Chonbuk national Univ., Korea, 2005.
5. Q. H. Zheng, et. al, " Clay –based polymer nanocomposites: Research and commercial Development", Journal of nanoscience and nanotechnology, Vol. 5, 1574-1592, 2005.
6. P. Meneghetti, S. Qutubuddin, "Application of mean-field model of polymer melt intercalation in organo-silicates for nanocomposites", journal of Colloid and Interface Science, 288, 387-389, 2005.
7. D. R. Paul, M. L. Robeson, " Polymae nanotechnology: Nanocomposites", Polymer 49, 3187-3204, 2008.
8. A. Yasmin, J. L. Abot, " Processing of clay /epoxy nanocomposites by shear mixing", Northestern Univ., IL, USA, 2003.
9. N. Sheng, et. al., " Multiscale micromechanical modeling of polymer/clay nanocomposites and the effective clay particle" polymer 45, 487-506, (2004).
10. K. Nogi, et. al, " Handbook of nanoparticles", JWRI, Osaka Univ., Osaka, Japan, 2007.
11. Refat El-Sheikhy, Mosleh Al-Shamrani," General Analytical Concept and Methodology of Design and Producing of Clay – Based Polymer Nanocomposite", American Ceramic Society Book Series. WEILY Publisher, 2010.
12. Refat El-Sheikhy, Mosleh Al-Shamrani," Morphology and Characterization of Saudi Arabian Natural Smart Nano Silicate Minerals", Advances in Applied Plasma Science,Vol. 7, Hampurg, Germeny, 2009.
13. Refat El-Sheikhy, Mosleh Al-Shamrani, Kobayashi Akira, "Structure and Analysis of Nano Silicate-Aluminum Layers Based on (RM-K) Fracture Theory", J. of Transactions of JWRI, Vol. 38, No.2, 2010.
14. R. El-Sheikhy, N. Masaaki,"On the Concept and Mechanism of (MN – r_p – σ_θ) Fracture Theory", Int. J. Transaction of JWRI, Vol. 34, No.2, 2006.
15. R. El-Sheikhy, N. Masaaki "Fracture speed and safe life history of structures before collapse by Fracture Analysis at Joining zones of composites of Dissimilar Materials", JWRI Symposium, Osaka Univ., pp.153-160, 2005.