NANO 2016, Québec, Canada

Enhancement of the thermal and electrical properties of LDPE by graphene fillers

Tung Tran Anh[1,2], Andrea Pirondelli[3], Michel Fréchette[4], Éric David[2], Claudiane Ouellet-Plamondon[2], Davide Fabiani[3]

[1]Electric Power University, Hanoi, Vietnam.
[2]École de Technologie Supérieure, Montréal, Canada.
[3]Dipartimento di Ingegneriadell'EnergiaElettrica e dell'Informazione "Guglielmo Marconi," Bologna, Italy.
[4]Hydro Québec's Research Institute, Varennes, Canada.
*e-mail: tungta@epu.edu.vn

The materials, preparation methods and characterization are the key factors in the field of nanodielectrics. All these things decide the interface region and its composition that attribute differently to the final properties of the composite materials. Therefore, this study has been conducted to have more understandings on the influence of these factors.

Graphene-based fillers with different sizes were used: Graphene oxide (GO) nanofiller, functionalized graphene (G*) and multi-phase graphene/clay (MP G*)micropowders. The choice of these derived products of graphene is by the fact that pristine graphene is not compatible with the polymer matrix and does not form homogenous composites [1]. In contrast, GO is hydrophilic which significantly alters the platelets interactions and leads to a more compatible filler with organic polymers [2-3]. It was also found that surface modification by chemical functionalization of graphene is essential in order to obtain a molecular dispersion of graphene layers in a polymer matrix [4]. The functional groups attached to the edge of graphene sheets can enhance the interaction of the filler with organic polymers.

In order to mix these fillers with the low density polyethylene (LDPE), several preparation methods were used:

1 - In the simplest way, graphene –based fillers were mixed manually with LDPE powder.

2- By ball-milling - the LDPE and fillers powders were manually premixed. The mixture powder was then milled with different preparation time: 40 minutes and 2 hours using 15-mm diameter balls in a zirconium oxide crucible using high – energy shaker mill. Ball milling was performed at ambient temperature and the weight ratio ball/powder was 10:1.

3- By melt-compounding method - the manually premixed composite powders were mixedusing a mini-extruder at 140°C during 20 minutes.

The obtained composite samples were then analyzed by different characterization techniques. The results can be summarized as following:

- From the BDS characterization, differences in the complex permittivity as a function of frequency can be observed between the samples obtained by milling, melt-compounding and hand mixing.
- The conductivity measured at a field of 3kV/mm of LDPE/G* is higher than that of LDPE/MP G* for all content-values of graphene fillers.
- Improvements are detected with the TGA characterization for both types of composites: the thermal stability exhibits an increase compared to that of the neat LDPE.
- In term of surface resistance, LDPE/G* exhibited higher resistance to erosion volume than neat LDPE and LDPE/GO.

In conclusion, it was found that the nature and preparation method of graphene based

fillers affect the thermal and electrical properties of LDPE/graphene composites. This is most probably due to the differences in dimension and dispersion degree of fillers and resulting effect on the morphology of the host polymer.

References

[1]T. Kuilla, S. Bhadra, D. Yao, N.H. Kim, S. Bose and J.H. Lee, “Recent advances in graphene based polymer composites,” Progress in Polymer Science, vol. 35, Issue 11, pp. 1350-1375, November 2010.

[2]A.K. Dikin, S. Stankovich, E.J. Zimney, R.D. Piner, G.H.B. Dommett, G. Evmenenkoet al. ,“Preparation and characterization of graphene oxidepaper,” Nature, vol. 448, pp. 457–460, 2007.

[3] L. Vickery L, A.J. Patil, and S. Mann, “Fabrication of graphene-polymer nanocomposites with higher-order three-dimensional architectures,” Advanced Materials, vol. 21, pp. 2180-2184, 2009.

[4] K.A. Worsley, P. Ramesh, S.K. Mandal, S. Niyogi, M.E. Itkis and R.C. Haddon, “Soluble graphene derived from graphite fluoride,” Chemical Physics Letters, vol. 445, pp. 51-56, 2007.