Dielektrinės ir triboelektrinės UIO-66/PEBA kompozitų savybės

Dielectric and triboelectric properties of UIO-66/PEBA composites

Martynas Kinka[1], Linards Lapčinskis[3], Sergejus Balčiūnas[1], Robertas Grigalaitis[1], Gediminas Usevičius[1], Fa-Kuen Shieh[2], Andris Šutka[3] and Jūras Banys[1]
[1]Faculty of Physics, Vilnius University, Sauletekio av. 9, LT-10222 Vilnius, Lithuania
[2]Department of Chemical Engineering, National Taiwan University, Taipei 10617, Taiwan
[3]Institute of Materials and Surface Engineering, Faculty of Materials Science and Applied Chemistry, Riga Technical University, P. Valdena str. 3/7, Riga LV-1048, Latvia
martynas.kinka@ff.vu.lt

In recent years, a search for materials possessing higher triboelectric performance has intensified. This interest stems from the desire to find materials suitable for enhancement of triboelectric nanogenerator (TENG) device efficiency. TENG devices, introduced in 2012, represent a pioneering concept to convert surplus mechanical energy into electricity, thereby allowing to power autonomous micro devices. This innovation shows significant promise to mitigate the environmental impact associated with the traditional energy production and battery usage.

Recently UIO-66 metal-organic frameworks (MOFs) with various linker modifications were identified as promising filler materials in mixed matrix membranes (MMM) for TENG devices [1]. Such composites allow preservation of the original excellent properties and low preparation cost of polymers while the addition of functional fillers can effectively improve triboelectric properties of the membranes [2,3]. Energy harvesting is mainly affected by charge-inducing ability (surface properties) and charge-trapping capability (dielectric property) of triboelectric materials. MOFs contain metallic and organic counterparts thus different contact electrification mechanisms may coexist. In this study we have focused on broadband dielectric properties of several selected polyether block amide (PEBA)/UIO-66 mixed matrix membranes aiming at investigation of dynamic processes and filler/matrix interaction in these composites.

PEBA-based nanocomposite films were prepared with 0.1, 0.2, 0.5, 1, 2 and 5 wt% UIO-66 and modified UIO-66-NH2 concentrations. Dielectric properties of these MMM were measured in 150 K – 360 K ant 1 Hz – 1MHz frequency range using computer controlled ModuLab XM MTS impedance measurement system and compared with the response of vanilla polyether block amide sample. This allowed us to identify the influence of the filler/matrix interaction on the glass transition and melting/crystallization relaxations of polyether (PE) and polyamide (PA) segments. Incorporation of UIO-66 crystallites increases glass transition temperature in PEBA matrix. On further heating Maxwell-Wagner relaxation process of interfacial polarization resulting from the existence of well separated phases involving ionic charge carriers was observed. Modification of UIO-66 linkers with -NH2 groups showed much stronger MOF-polymer interaction and increase in dielectric permittivity as compared with pure UIO-66 MMM.

Results of composite contact-separation show that at concentrations below 0.2 wt.% the addition and also the type of MOF makes no great influence on the triboelectric properties of the composite. However, when UiO-66 content reaches 0.5 wt.% the UiO-66/PEBA composites tend to obtain a negative charge while UiO-66-NH_2/PEBA composites remain positively charged. For UiO-66-NH_2/PEBA composite film content of 2 wt.% was found to yield the highest charge density, however the increase is small. At the same time, for UiO-66/PEBA the optimal content of MOF filler was seen at 1 wt.%. At this content the UiO-66/PEBA composite reached charge density of -3.0 nC cm^{-2}.

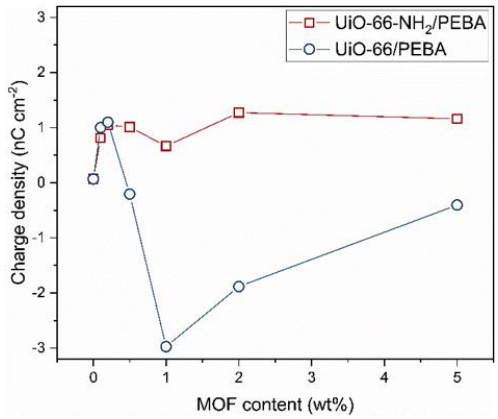

Figure 1. Charge density of UiO-66/PEBA and UiO-66-NH_2/PEBA composite based contact layers as a function of MOF content in them.

Keywords: dielectric, triboelectric, TENG, MOF

References

[1] Y.-M. Wang, Nanotechnology, 2022 10.1088/1361-6528/ac32f8
[2] A. Šutka Adv. Mater. Technol, 2022, 10.1002/admt.202200162
[3] Y. Hu, Macromol. Mater. Eng., 2021, 10.1002/mame.202100128
.