Synthesis and Characterization of Perovskite Oxide Reinforced Polymer Nanocomposites

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Microscopy and Microanalysis, **29** (Suppl 1), 2023, 1825–1826
https://doi.org/10.1093/micmic/ozad067.944

Microscopy AND Microanalysis

Meeting-report

Synthesis and Characterization of Perovskite Oxide Reinforced Polymer Nanocomposites

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Polymers derived from natural resources are abundant and promising materials, as environmentally benign alternatives for non-degradable polymers. These natural polymers, such as chitosan, cellulose and starch [1], are favorable candidates for a variety of applications, such as gel electrolyte and separator membranes for Li-ion batteries, dye-sensitized solar cells, supercapacitors, fuel-cells, etc. However, these polymers have shown limited mechanical properties as compared to non-degradable petroleum-based polymers [2]. Therefore, these polymers are often used in conjunction with non-degradable polymers, making them partially degradable or by adding nanofillers to achieve favorable functionality so that they are comparable to synthetic polymers.

Nanostructured layered materials are successfully used as fillers in several polymer matrices. The intercalation and exfoliation of 2D layers resulted in the improved mechanical and tribological properties of the polymers, in addition to some functionality of the filler. Such layered fillers are increasingly sought as a type of reinforcement for biodegradable green polymers for packaging and related applications. The incorporation of nanofillers is also a promising strategy to overcome shorter shelf life and undesirable crystallization characteristics of some green polymers. Furthermore, nanostructured fillers can improve the processibility of green polymers. However, the layered nanofillers in the polymer-matrix composites are frequently limited to improve the physical properties of the composites. To ascertain a unique functionality to a polymeric material, nanomaterials with targeted functionality should be used as the nanofillers. Layer perovskites have been reported, such as the Ruddlesden–Popper phase, Dion–Jacobson phase, and Aurivillius phase [3]. In this work, we synthesis naturally derived polymers reinforced with exfoliated perovskite oxide sheets in the polymers.

The $K_2La_2Ti_3O_{10}$ (KLTO) was synthesized using modified Pechini method [4, 5]. The $K_2Gd_2Ti_3O_{10}$ (KGTO) was synthesized by a solid-state reaction method. A proper stoichiometric ratios of the precursors K_2CO_3, Gd_2O_3 and TiO_2 were placed in a mortar-pastel for homogeneous mixing. The gadolinium precursor was replaced by 5% Eu_2O_3 precursor. These powder granular precursors were crushed into a very fine powder and mixed very well for 40 min. The fine powder product was transferred to an alumina crucible and heated in an air furnace at first at 550 °C for 2 h, then at 1,150 °C for 6 h, followed with furnace cooling to room temperature. Further, the product was crushed into fine white powders to synthesize nanocomposites in the matrix of polyvinylidene fluoride (PVDF) and its copolymer, polyvinylidene fluoride-trifluoroethylene (PVDF-TrFE).

The XRD patterns of bulk and exfoliated $K_2La_2Ti_3O_{10}$ (KLTO) are shown in Fig. 1a and 1b, respectively. The bulk sample exhibits high crystallinity. The exfoliated structure is shown in Fig. 1c showing layered structures. The SEM image KGTO powder is shown in Fig. 1d. The SEM image of the KLTO/ PVDF-TrFE composite is shown in Fig. 2a, and elemental maps of K, La, Ti and O are shown in Fig. 2b–e, respectively, exhibiting uniform distribution of the elements indicating a high dispersion degree [6–8].

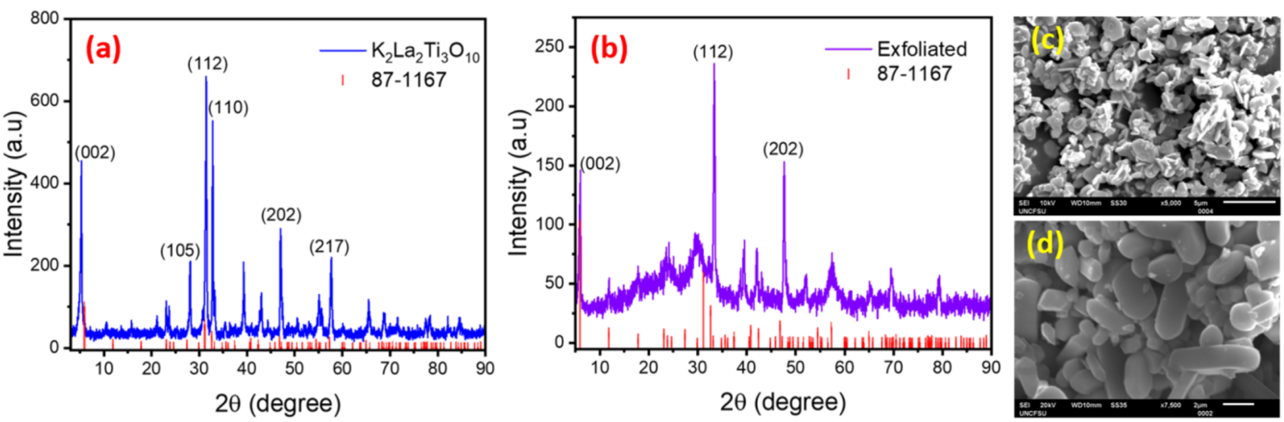

Fig. 1. XRD patterns of bulk (a) and exfoliated (b) KLTO, and SEM of KLTO (c)and KGTO (d).

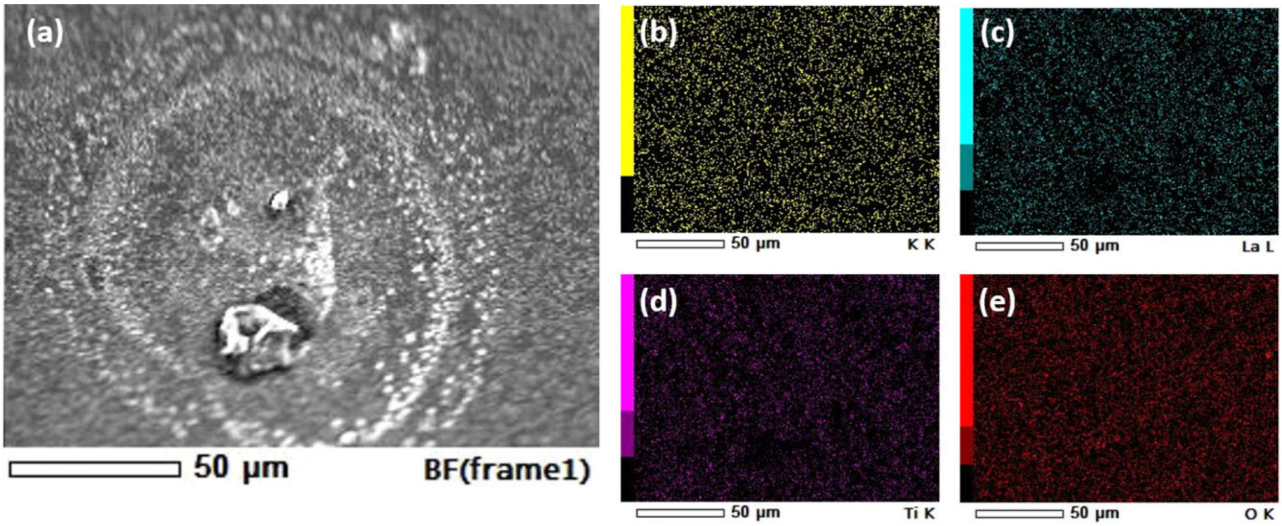

Fig. 2. SEM image of KLTO/PVDF-TrFE composite (a) and elemental maps (b–e).

References

1. M Lee, *et al.*, *Appl. Sci.* **5** (2015), p. 1272. doi:10.3390/app5041272
2. KJ Jem, *et al.*, *Adv. Ind. Eng. Polym. Res.* **3** (2020), p. 60. doi:10.1016/j.aiepr.2020.01.002
3. G George, SR Ede and Z Luo in "Fundamentals of Perovskite Oxides: Synthesis, Structure, Properties and Applications", (CRC Press, Boca Raton, Florida).
4. SR Ede, *et al.*, *Microsc. Microanal.* **28** (2022), p. 2664. doi:10.1017/S1431927622010091
5. SR Ede, *et al.*, *ACS Catal.* **11** (2021), p. 4327. doi:10.1021/acscatal.1c00465
6. ZP Luo and JH Koo, *J. Microsc.* **225** (2007), p. 118. doi:10.1111/j.1365-2818.2007.01722.x
7. ZP Luo, *J. Mater. Sci.* **45** (2010), p. 3228. doi:10.1007/s10853-010-4330-x
8. This collaborative work between FSU and TU was supported by NSF EES 2106181.