Antibiofilm and antibacterial activity of Ag-intercalated upconverting Tm^{3+}/Er^{3+} co-doped layered perovskites and their exfoliated 2D nanosheets

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Antibiofilm and antimicrobial materials are in great demand in the medical device industry. Although Ag-based compounds are known to have high antimicrobial efficiency, rapidly released Ag^+ ions tend to aggregate and lose their antibacterial effect over time [1]. Thus, utilizing a new approach for using silver as an antimicrobial agent based on imparting the antimicrobial action through contact, rather than releasing Ag^+ ions could be beneficial. We previously demonstrated the upconversion properties of Tm^{3+}/Er^{3+} co-doped Ruddlesden-Popper (RP) type perovskite $K_2La_2Ti_3O_{10}$ (KLTO) and their chemically exfoliated nanosheets [2]. In the present work, we performed Ag-intercalation of Tm^{3+}/Er^{3+} co-doped KLTO layered perovskites and the nanosheets via ion-exchange process to increase their antibacterial activity. We investigated the effect of Ag-intercalated Tm/Er co-doped layered perovskites and their 2D nanosheets on the growth and biofilm formation of the human opportunistic pathogens *Escherichia coli* and *Bacillus subtilis*. Importantly, flocculation of nanosheets with Ag^+ ions significantly increased their antibacterial and antibiofilm activity against both species (Fig 1). Strikingly, the flocculated nanosheets demonstrated significant growth inhibitory effects at 100 µg/mL and 1000 µg/mL. At both concentrations, bacteria were not able to grow in LB broth and so no spectral readings were obtained for the 12-hour growth graph (Fig 2). In addition, the flocculated materials demonstrated low *in vitro* cytotoxicity when incubated with mammalian cell lines. Our results indicate that Ag-intercalated layered perovskites and the flocculation of the nanosheets hold great promise to be used for antimicrobial and antibiofilm purposes in biomedical engineering applications. This work was supported by the Scientific and Technological Research Council of Turkey (TÜBİTAK; Grant number 117M512).

References

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[2] Gunay B, Sarıyar E, Unal U, Karagonlar ZF, Sağlam Ö., Colloids and Surfaces A: Physicochemical and Engineering Aspects, 126003 (2021)

Figures

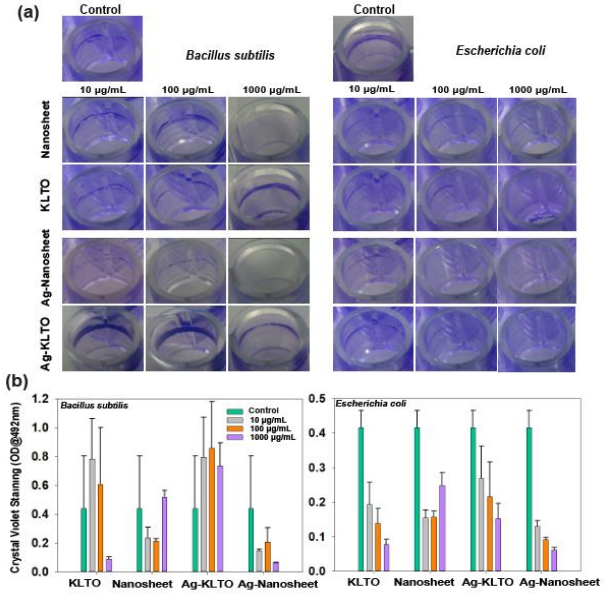

Figure 1. Antibiofilm properties of Tm^{3+}/Er^{3+} co-doped samples before and after Ag intercalation determined by crystal violet staining.

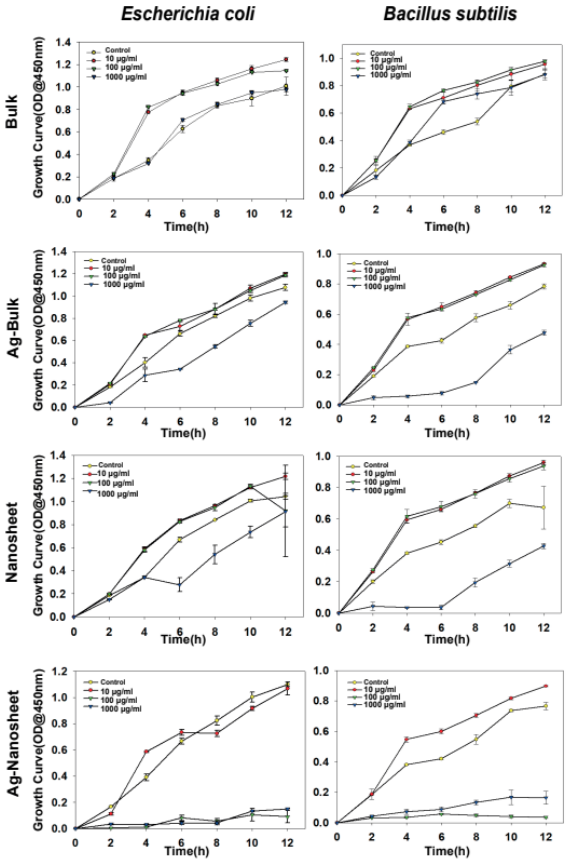

Figure 2. Growth curves of E.coli and B. Subtilis incubated with Tm^{3+}/Er^{3+} co-doped samples before and after Ag^+ ions intercalation.