A novel scalable method for synthesis of metallic anisotropic particles

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Anisotropic particles are the emerging class of materials where the physical and/or chemical anisotropy of a material not only combine various functionalities in a single body but also may benefit from synergy or the directionality of such properties (Figure 1). The way of the distribution of components in anisotropic particles gives rise to the development of new stimuli-responsive, programmable, synergistic or advanced materials. Janus particles, for instance, exhibit the extreme case of anisotropy, where two components are placed at two opposite sides of the particle (Figure 1a). Synthesis of Janus and other anisotropic structures has been advanced significantly for polymeric materials in last few decades. However, even though the metallic anisotropic structures offer a wider spectrum of properties and application areas, their synthesis is still a challenge as it is complicated and difficult to achieve. The currently available techniques successfully demonstrate the ability of synthesis and immense potential of metallic anisotropic structures in applications; however, they either require very special conditions for synthesis or produce particles with significant defects; therefore, they are far from being scalable. Besides, the examples of material combinations are rather limited.

In this presentation, we will introduce a novel technique for fabrication of metallic anisotropic structures that is simple, robust, scalable and environmentally friendly. The abilities of the technique will be demonstrated on the fabrication of anisotropic Bismuth-Tin (Bi-Sn) and will exemplify its synthesis in various size and forms, including the Janus structure. The particular emphasis will be given to the robustness of the technique as all particles that will be presented are synthesized using the exactly same technique but only with the felicitous control of its synthesis conditions. The topology, chemistry, and crystallographic structure of particles are thoroughly characterized. The chemical distribution in a particle is shown by slicing the particle using focus ion beam technique and show that the anisotropy is not only on the surface (core-shell), but it is throughout the particles (coreless). Therefore, to the best of our knowledge, this technique is the first scalable technique that can produce coreless metallic Janus and other anisotropic structures. In this study, the Bi-Sn system is only considered as a model system, thus the findings can be elaborated on the other systems as the technique allows easy adjustments over other combinations.

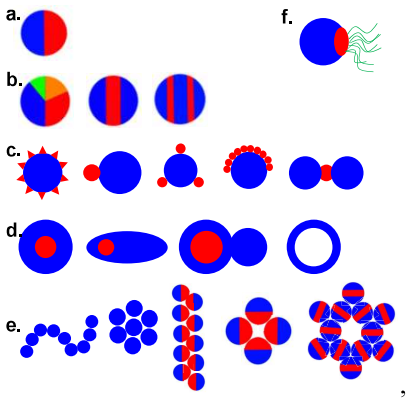

Figure 1. Types of anisotropic particles: a) Janus, b) multi-compartmental, c) Patchy, d) core-shell, e) examples of assembly possibilities. From left to right, complexity increases. f) Functionalized particle. Different colors indicate chemical varieties.

Acknowledgments: Funding provided by TUBITAK (Scientific and Technological Research Council of Turkey) under Grant No. 117C025 is gratefully acknowledged.