Journal of MATERIALS RESEARCH

DOI: 10.1557/jmr.2019.272

This special issue of the Journal of Materials Research contains articles that were accepted in response to an invitation for manuscripts.

Introduction

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Hierarchical and other advanced materials have attracted increasing attention due to their unique physical and chemical properties, which strongly depend on morphology and size [1, 2]. These materials have been applied in important technological fields such as energy, catalysis, optical devices, water purification, pollutant removal, CO_2 sequestration, and biomedicine [3, 4, 5, 6, 7]. Particle-based crystallization and self-assembly of molecules are important pathways to synthesize advanced materials of complex structures [8, 9, 10, 11]. Unlike monomer-by-monomer addition or Ostwald ripening, particle-based crystallization occurs via particle-by-particle addition, to form larger crystals or clusters [8, 12]. To date, numerous advanced materials have been synthesized in the lab using particle-based crystallization. Examples include metals such as Pt, Pd, Au, Ag, and Cu [13]; alloys such as Pt–Ni, Pt–Cu, Pt–Fe, and Au–Ag [14]; metal oxides such as ZnO, TiO_2, CuO, and α-Fe_2O_3, Fe_3O_4 [15, 16, 17, 18, 19]; and metal sulfides such as PbS, PbSe, ZnS, and CdS [20, 21]. In addition, particle aggregation-based crystallization has been observed in nature, such as in various geological and biological minerals including calcite, collagen, and others [22, 23, 24]. Different from the particle-based crystallization, self-assembly of molecules has also been used to build advanced materials such as molecular clusters and nanoparticles. For instance, advanced luminescent materials have been prepared by aggregation-induced emission (AIE) of intrinsically non-emissive molecules [25, 26]. One of the challenges facing this fast-growing field of advanced materials is to develop a fundamental understanding of the interactions between particles or molecules in a growth medium and the resulting response dynamics.

This Focus Issue will cover a broad range of topics about building advanced materials via particle aggregation and molecular self-assembly, from experiment and theory to application. One topic covers the synthesis of advanced materials via particle-based crystallization and self-assembly of molecules and their application in energy, catalysis, water purification, pollutant removal, etc. For example, several papers will introduce novel methods to synthesize diamondoids nanowire-cluster arrays [27], hierarchical Au-loaded SnO_2 nanoflowers, multi-branched gold nanostructures [28], graphene oxide coated popcorn-like Ag nanoparticles [29], hierarchically porous poly(lactic acid)/poly(ε-caprolactone) monolithic composites [30], 3-dimensional-graphene/Cu/Fe_3O_4 composite, as well as others, and the application of hierarchical materials in surface-enhanced Raman scattering [28], Cr(VI), organic dyes, and oxytetracycline removal [31, 32], photocatalysis [33], supercapacitor, bisphenol A detection, and gas sensing. Another topic includes investigations of growth mechanisms, such as exploring the growth mechanism of WO_3 nanocubes [33]. The most important topic concentrates on understanding the driving forces for particle and molecular aggregation. Particle aggregation strongly depends on the interparticle interactions such as van der Waals (vdW), electrostatic, ion-correlation, hydration, and magnetic forces [34]. Understanding these interaction forces could aid in developing methods to control their aggregation behaviors and then build advanced hierarchical structures. Recently, advanced techniques have been developed to directly measure the interactions between nanoparticles, and the results have clearly shown the roles of vdW and hydration forces on the nanoparticle aggregation [34, 35, 36]. An invited review in this Focus Issue summarizes these force measurement techniques, and also highlights the theories and simulations on the driving forces for particle aggregation [37]. The final topic considers building materials with aggregation-induced emission (AIE) and their applications. Several manuscripts discuss the synthesis of small organic molecules containing diphenylmethylene, carbazole and malononitrile units, and polymers and how their AIE properties are used for cell imaging [38, 39]. The aim of this Focus Issue is to provide a platform for interdisciplinary researchers from physics, chemistry, geology, biology, engineering, and material science to share their approaches to understand and control molecular and particle-based mechanisms of advanced material formation in order to design novel functionalized materials.

Finally, we are very grateful to both the authors and reviewers of the many high-quality manuscripts submitted to this *JMR* Focus Issue on Building Advanced Materials via Particle Aggregation and Molecular Self-Assembly.

On the cover

The cover of this Focus Issue shows a novel kind of high performance coaxial wire-shaped supercapacitors (WSSCs) with ionogel electrolyte was assembled. Highly flexible WSSCs can be woven into wearable fabrics and devices clearly suggests the possible potential utilization of the textile structures for commercial usage in the future. This method can be utilized in industrial scale to fabricate a device to store and supply energy to portable electronic appliances during a power outage in the grid lines as this device can be charged using wind power.

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