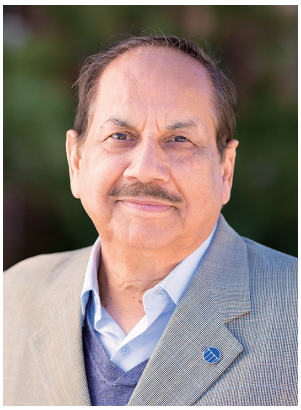
Editor's Preface



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As Chair of the American Editorial Board, I am pleased to introduce the KONA Powder & Particle Journal No. 42. Consistent with our tradition, this issue contains 13 high-quality reviews and 4 original papers.

It is no secret that with the explosive growth of artificial intelligence/machine learning (AI/ML) modalities, we are witnessing a unique opportunity to not only realize phenomenal growth in practical applications of particulate systems, but also to overcome certain long-standing challenges that have impeded particle technologists over the ages. Through judicious integration of AI, particle technologists can reduce the cost of production and accelerate the development of customized functionalities that might not otherwise be feasible by traditional methods.

Particle technologies continue to play a vital role in advancing useful developments in a wide variety of industries, from food to pharmaceuticals and mining to microelectronics, and beyond. The use of tailored powders in additive manufacturing is growing, particularly in industries like aerospace, automotive, and healthcare. Particle technologies offer the potential for the development of novel materials with improved mechanical properties and complex geometries. Nanoparticles with specific functionalities (e.g., magnetic, optical, electronic, or catalytic properties) can be used in applications such as imaging, sensors, and energy harvesting. These particles enable the creation of new products and technologies with enhanced performance across various sectors, including healthcare and electronics. Particle technologies are being explored for enhancing bioavailability of nutrients, and in precision agriculture for controlled release of fertilizers and pesticides. These advancements could lead to more sustainable food production and improved nutritional quality. In energy production, particle technologies are important for applications like solar panels, fuel cells, and batteries. Enhanced energy efficiency and the development of sustainable, renewable energy solutions can be achieved through the optimization of particle-based systems.

Collaborative approaches between academic researchers in particle technology and AI/ML, and contract manufacturers (CMOs) and research organizations that specialize in scaling up particle-mediated processes provide a unique opportunity to develop robust system specific scale up protocols.

Where there are opportunities, challenges are to be expected. The production and handling of nanoparticles and fine particulates can pose health risks, including respiratory issues or toxicity, as well as environmental contamination. The toxicity of nanoparticles is highly dependent on their specific characteristics, such as size, shape, composition, and surface properties. While some nanoparticles have shown toxic effects, particularly in high doses, many nanoparticles and nanostructures have been successfully designed to minimize risk and maximize therapeutic or functional benefits. Ongoing research is beginning to address these challenges, but the rapidly evolving field of nanotechnology requires constant updates in both research and policy to ensure safe use.

AI will be transformational for the field of nanotechnology. Models can simulate complex particle interactions in

various media (liquids, gases, biofluids etc.), predicting agglomeration, sedimentation, or dispersion properties. This can help optimize the use of particles in applications such as functional coatings, advanced composites, healthcare, and pharmaceuticals.

High throughput particulate mediated experimentation is still under development. However, AI has the potential to expedite reliable data acquisition by automating the experimentation process. At the same time, robotic systems equipped with AI may enable rapid testing of different particle formulations and conditions.

Although numerous applications of AI/ML systems for on-demand commercial production of nanoparticles and nanostructures have been proposed, practical applications of AI are not without challenges. For example, ongoing collaborative efforts have revealed that the scarcity of high-quality, standardized data is a critical barrier to developing robust and reliable nano-QSAR models. One of the primary issues is the lack of availability of sufficient number of uniform datasets, since different experimental groups have employed different assays, and different biological systems. This makes it challenging to develop computational models that are universally applicable, since minor changes in nanoparticle composition can lead to vastly different toxicological outcomes. Additionally, validating these models is challenging due to the limited availability of comprehensive external datasets and the difficulty in defining the applicability domain—i.e., the range of nanoparticle properties for which the model predictions are dependable. Integrating these models into regulatory frameworks is further complicated by the need for standardized guidelines and protocols, which require coordination among researchers, regulatory bodies, and industry stakeholders to ensure these computational tools are effectively and appropriately used in nano-safety assessments.

It is interesting to note that despite the myriad AI/ML challenges, a recently published paper has illustrated the potential of using ChatGPT-4 and LLM (Large Language Models) to write an original pharmaceutics manuscript. Although the results generated appeared plausible, the authors strongly advise that human interpretation and validation are necessary to enhance AI capabilities in generating robust data that may be suitable for practical applications.

On the educational front, artificial intelligence has wide-ranging potential. For example, AI-powered platforms are already offering personalized tutoring. For educators, AI can help tailor instruction to meet individual student needs and predict which students may require additional support for understanding a specific topic.

Overall, I believe harnessing the application of AI/ML and advanced computational tools has the potential of stimulating both the instruction and applications of particle and powder technology for continued societal benefit. However, the need for domain expertise is going to be ever more critical to make proper use of AI/ML tools, which otherwise may lead to highly risky developments. Regarding our collaborative efforts to ensure KONA's continued relevance and reputation as a foundational source of particle and powder technology knowledge, more review papers authored/coauthored by current and past industry researchers and practioners are highly desired to further enrich KONA's literature and library. Mini reviews on emerging topics by younger professionals is another opportunity to present breaking developments to KONA readers.

I would like to close by thanking all the authors and reviewers who have contributed to the "KONA Powder and Particle Journal" Issue No. 42. Their research, contribution and partnership have been instrumental in making this edition a success and ensuring that we all have an eye on the future of KONA and the technologies on the horizon with respect to which our expertise will be sought.

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American Editorial Board
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