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In Quest of a Systematic Framework for Unifying and Defining Nanoscience[1]

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A *central paradigm driven, Mendeleev-like nano-periodic system* has been cited as a critical missing link in the transformation of nanotechnology from an empirical to a highly predictive science. A systematic framework is proposed based on the same first principles underpinning "central paradigms" for chemistry/physics.[2] As such, a **Nanomaterials Classification Roadmap** considers *structure controlled* nanoparticles defined by **Critical Nanoscale Design Parameters (CNDPs);** namely, **size, shape, surface chemistry, flexibility, architecture and elemental composition**. Classified as either **hard (H) (**inorganic) or **soft (S) (**organic) **nano-element categories**,these nanoparticles (e.g., nano-clusters) generally manifest pervasive **atom mimicry** features.[3] Many literature examples demonstrate chemical bonding/assembly of these nano-element categories to produce extensive libraries of **hard-hard** $[\mathbf{H}_n\mathbf{:}\mathbf{H}_n]$, **soft-soft** $[\mathbf{S}_n\text{-}\mathbf{S}_n]$**or hard-soft** $[\mathbf{H}_n\text{-}\mathbf{S}_n]$ nano-element combinations, referred to as **nano-compounds**. Due to their quantized CNDP features, these nano-element/compounds exhibit many well-defined **nano-periodic property patterns**. These property patterns are observed in their intrinsic physico-chemical properties (i.e., melting points, reactivity/self-assembly, sterics), as well as important functional/ performance properties (i.e., magnetic, photonic, and electronic behavior). The importance of these CNDP directed property patterns was recently demonstrated by publication of **first Mendeleev-like nano-periodic tables** by Percec, et al.[4] Similarly, Mirkin, et al.[5] recently reported six CNDP dependent nano-periodic rules for predicting hard-soft nano-element assemblies. These two independent reports appear to fulfill/validate this proposed nano-periodic concept. This lecture will overview this unifying **nano-periodic system** suitable for tuning optimal nanostructure/application properties, as well as predicting important risk/benefit/performance boundaries in the nanoscience field.

[1]NSF

[2]D.A. Tomalia, *J. Nanopart. Res.* (2009), 11, 1251.
[3]S.N. Khanna, A.W. Castleman, et al., *PNAS* (2006), 103 (49), 18405.
[4]V. Percec, et al., *J. Am. Chem. Soc.* (2009), 131, 17500.
[5]C.A. Mirkin, et al., *Science* (2011), 334, 204.