Visualizing Structure of Bio-Functional Magnetic Nano-Particles with Analytical Electron Microscopy

Jie (Joyce) Wang, Lingyan Wang, Ann Ferrie, Yan Jin.
Corning Incorporated.

Statement of Purpose:
In this report, we utilized the analytical electron microscopy to directly image the structures of the functional magnetic nano-particles (MNP) and the interaction between bio-specimen and magnetic particles. This direct imaging technique enables us to correlate the microstructure of magnetic particles with their corresponding performance so that we can further improve the design of our products to achieve optimized performance.

Methods:
Corning scientists have been working on synthesizing magnetic nano-particles (MNP) with the capability of controlling particle size, composition, crystalline structure, and uniformity, followed by novel surface modifications for different biological applications. Transmission electron microscopy has been well-known as an imaging techniques which can directly measure the size, crystallinity and uniformity of Corning MNP. Furthermore, Chemi-STEM, the new FEI technology which designed for acquisition of chemical information on the atomic scale, enable us to see the composition of these extremely small particles.

Results:
In figure 1, Chemi-STEM EDX element maps of carbon (functional surface polymer) and iron (MNP) are overlapped in the same images for Corning and commercially available MNPs. We visualized the microstructure of these partciles, core-shell or mosaic.

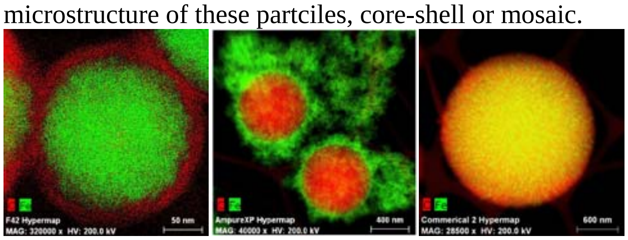

Figure 1. EDX hypermap element maps of C and Fe for magnetite nanoparticles made by Corning (left) and first commercially availableparticle (middle) and second commercially available particle. (right).

In figure 2, Chemi-STEM EDX element maps of phosphorus and iron are overlapped in the same pictures for Corning MNP before (left) and after (right) binding with DNA. Green color was an iron element from iron oxide of Corning MNP. Purple color was a phosphorus element from DNA. The data suggested that the magnetic beads were surrounded by DNA molecules after binding with DNA. While for the particles without binding with DNA, no phosphorus structure was detected as expected. This indicates that the branched PEI capped magnetic nanoparticles have the proper surface for DNA binding.

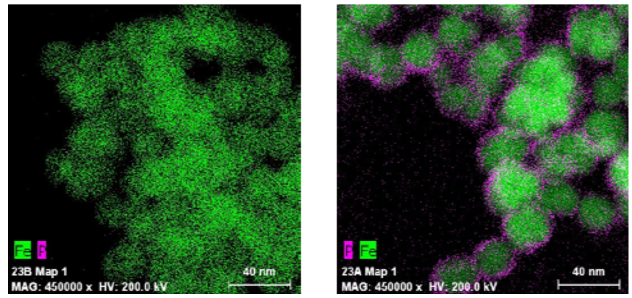

Figure 2. EDX hypermap element maps of P and Fe for branched PEI capped magnetite nanoparticles before (left) and after (right) binding with DNA.

Conclusions:
The analytical electron microscopic images of bio-functional magnetic particles demonstrate the unique structures and how they function as designed in bio-applications. These results verify a simple and cost-effective approach to synthesize the surface modified magnetic particles with the capability of controlling particle size, crystalline structure, and uniformity. In addition, the feasibility of magnetic particles for DNA binding has also been demonstrated by these direct imaging results.

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