Development of Novel Nanomaterials for Water Remediation

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Background/Objectives. Nanotechnology has expanded significantly with its applications in almost all branches of industry, including the water purification field. Through the GAIA project, a research project funded by the Korea Ministry of Environment, our group has developed numerous nanomaterials for environmental applications, specifically focusing on wastewater and groundwater remediation. This presentation introduces the characteristics of each developed nanomaterial and proposes for their environmental applicability.

Approach/Activities. The recoverable and less toxic iron-based materials were mainly developed based on magnetite (Fe_3O_4) and nanoscale zerovalent iron (nZVI, nFe). To improve the reactivity and environmental applicability of existing iron-based materials, various methods (e.g., surface modification or immobilization to mesoporous support) have been used. Non-iron based materials were also developed using reactive materials such as bismuth and graphene oxide. These materials were studied to verify their reactivity in the field and some of them were directly injected into several actual contaminated sites in Korea for studying the field engineering parameters.

Results/Lessons Learned. The various methods were developed to enhance the dispersibility and selectivity of magnetite. For example, a medicinal substance such as nalidixic acid was modified on the surface of magnetite for selective adsorption, and also hierarchical MnO_2-coated Fe_3O_4 was developed, which had good sorption ability toward divalent heave metals. The magnetic mesoporous carbon (MC) was synthesized by in situ growth of nanoscale Fe_3O_4 on the surface of MC and phosphonate ligand was grafted additionally for the treatment of radioactive materials. Furthermore, eco-friendly bio-magnetite and iron sulfide (FeS) were synthesized by using microorganisms. Bismuth modified (Bi/nFe) and sulfidized nZVI (S/nFe) were developed and showed higher reductive abilities toward organic contaminants such as trichloroethylene and chlorophenols than the bare nZVI. One of the inorganic ligands, tetrapolyphosphate was also coupled with nZVI (TPP-nFe) to enhance the stability and reactivity of nZVI. In addition, highly reactive $AgBiO_3$ particles and graphene-based materials with high adsorption capacity were developed beside the iron-based materials. Among the developed nanomaterials, S/nFe, Bi/nFe and TPP-nFe were directly delivered into the contaminated source zones in large scale, showing promising results in degradation of TCE and BTEX.