

Chapter 10

Removal of Heavy Metal Ions Using Magnetic Materials



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Contents

1	Introduction	395
2	Magnetic Materials	395
3	Aspect of Magnetism	396
3.1	Diamagnetism	398
3.2	Paramagnetism	399
3.3	Ferromagnetism	399
3.4	Antiferromagnetism	399
3.5	Ferrimagnetism	400
4	Synthesis of Magnetic Particles	400
4.1	In Situ Methods	402
4.2	Ex Situ Methods	403
5	Magnetic Separation for Water Purification	403
6	Recovery of Magnetic Particles	405
7	Environmental Application of Magnetic Particles	406
	Glossary	406
	References	407

Abstract Heavy metal ions contaminate water environment through point sources and nonpoint sources. Heavy metal ions are categorized as inorganic contaminants by both the WHO and the USEPA. The heavy metal ions are increasingly being introduced into the environment as pollutants and contaminants resulting from human activities.

Magnetic particles for water treatment applications have received considerable attention from researchers due to high separation efficiency. The magnetic particles behave similar to or even better than various commercial adsorbents. The magnetic

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particles also exhibit high selectivity for the target pollutants from the environment besides enabling ease of operation for reducing the particle separation steps from the flowing stream. A comprehensive and systematic understanding of synthesis and surface modifications of magnetic particles is significant to enhance their practicality in environmental technology. Although high removal performance and reactivity can be achieved by smaller particle size, the stability, toxicity, and recovery of the particles magnetically could be challenging.

In contrast, the active surface of magnetic particles may be forfeited, while surface modifications stabilize and reduce the toxicity of the particles. Reliable surface modifications are necessarily needed for the increment of the number of active sites to remove the heavy metals. For successful environmental applications of the magnetic particles, modification on the magnetic particles is principally crucial to balance the effects on their reactivity, capacity, and reusability.

Keywords Heavy metal ions · Magnetic particles · Contaminants · Heavy metal · Adsorbent · Pollution · Removal · Separation · Magnetic sorption technology

Nomenclature

$\gamma\text{-Fe}_2\text{O}_3$	Maghemite
Ag	Silver
BH_{max}	Highest energy product
B_r	Remanence
Ca	Calcium
Cd^{2+}	Cadmium cation
CdS	Cadmium sulfide
CdSe	Cadmium selenide
Cu	Copper
Cu^{2+}	Copper cation
Co	Cobalt
Cr^{4+}	Chromium cation (4+)
Fe	Iron
FeO^-	Negative charge iron oxide
Fe_3O_4	Magnetite
Fe_3S_4	Greigite
Gd	Gadolinium
Hc	Coercive force
Hg^{2+}	Mercuric cation
HGMS	High-gradient magnetic separation
Mg	Magnesium
MIEX	Magnetic ion exchange resin
Mn	Manganese
MnFe_2O_4	Manganese iron oxide
MnO	Manganese(II) oxide
Mn-Zn	Manganese-zinc