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Magnetic separation of iron-based nanosorbents from watery solutions

Irina Medvedeva (1,2), Iuliia Bakhteeva (1), Sergey Zhakov (1), and Klaus Baerner (3)

(1) Institute of Metal Physics, Ural Branch of the Russian Academy of Sciences, 620990, Ekaterinburg, S.Kovalevskaya 18, Russian Federation (ivmedko@mail.ru), (2) Ural State Mining University, 620144, Ekaterinburg, Kuibysheva 30, Russian Federation (ivmedko@mail.ru), (3) 3 Department of Physics, University of Göttingen, F.Hund Platz 1, 37077 Göttingen, FRG (k.baerner@t-online.de)

Iron and iron oxide magnetic nanoparticles (MNP) both naked and with chemically modified surface are promising agents for different environmental applications, in particular for water purification and for analytical control of water and soil pollution. The MNP can be used as sorbents with selective abilities due to designed surface functionalization. While a lot of research has been devoted to the impurity sorption processes, the second part, that is the efficient removal of the MNP sorbents from the watery solution, has not been sufficiently studied so far. For that particles with magnetic cores are especially attractive due to the possibility of their subsequent magnetic separation from water without using coagulants, i.e. without a secondary water pollution, just by applying external magnetic fields B.

In order to remove magnetic sorbent nanoparticles (10-100 nm) effectively from the water solution gradient magnetic fields are required. Depending on the MNP size, the magnetic moment, the chemical properties of the solution, the water purification conditions , either the low gradient magnetic separation (LGMS) with $dB/dz < 100$ T/m or the high gradient magnetic separation (HGMS) with $dB/dz > 100$ T/m is used. The gradient magnetic field is provided by permanent magnets or electromagnets of different configuration.

In this work the sedimentation dynamics of naked Fe3O4 and Fe3O4@SiO$_2$ nanoparticles (10-30 nm) in water was studied in a vertical gradient magnetic field ($1 \leq 0.3$, $dB/dz \leq 0.13$ /cm). By this LGMS , the sedimentation time of the naked Fe3O4 NP is reduced down from several days to several minutes. The sedimentation time for Fe3O4@SiO$_2$ decreases from several weeks to several hours and to several minutes when salts Na2SO4, CaCl2, NaH2PO4 are added to the solution. The results are interpreted in terms of MNP aggregate formation caused by electrostatic, steric and magnetic inter-particle interactions in the watery solution.

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