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Al *K*-edge XAS and ^{57}Fe Mössbauer spectroscopy to elucidate Aluminum allocation in magnetically hard $BaFe_{12-x}Al_xO_{19}$ hexaferrites

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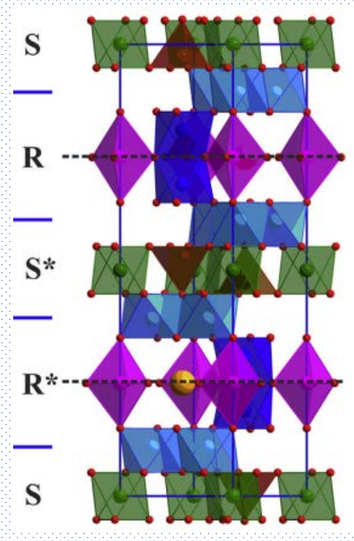
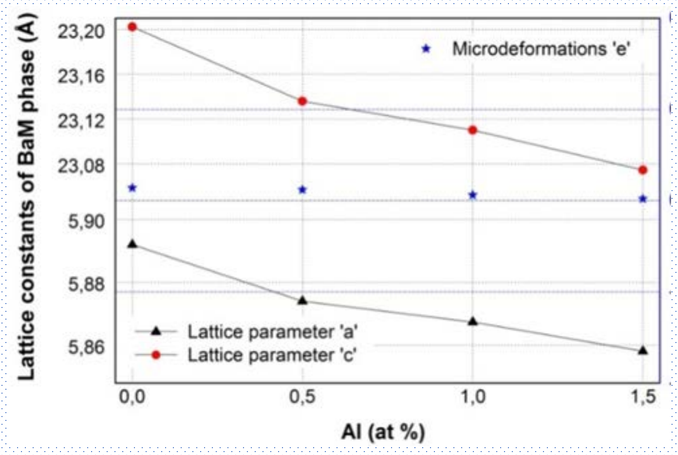
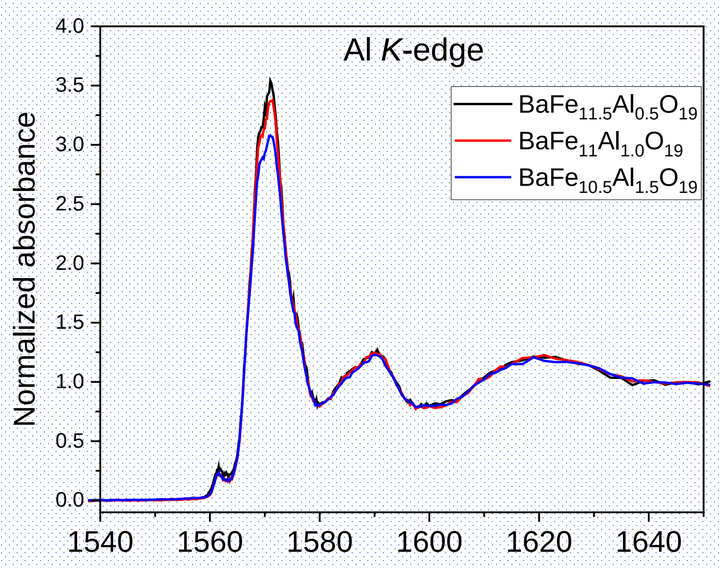
The magnetic properties of $BaFe_{12}O_{19}$ hexaferrite (BaM) are suitable for permanent magnets. It is well known that doping trivalent elements such as Al in hexaferrites can increase the coercivity and improve their capability for fabrication of permanent magnets. Specifically, the following system is being studied: $BaFe_{12-x}Al_xO_{19}$ ferrites doped with different concentrations of Al^{3+} (x = 0.5, 1.0, 1.5 at. %). We hereby conducted studies on the location of aluminum ions in the crystal lattice. The effect on the magnetic order of the hexaferrite is shown.



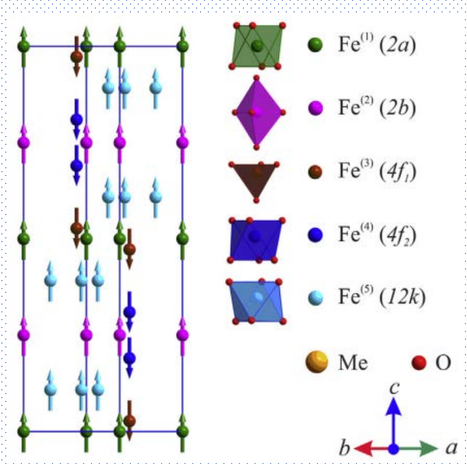
The crystal structure of $BaFe_{12}O_{19}$ lattice. The hexaferrite crystal structure is a sequence of stacked layers of oxygen ions with interstitial spaces that cations can occupy. The crystal structure of BaFe12O19 could be represented as a sequence of S and R blocks (SRS*R*). The asterisk indicates a 180° rotated block. The figure represents the iron ions with different colors attributed to different crystallographic sites.



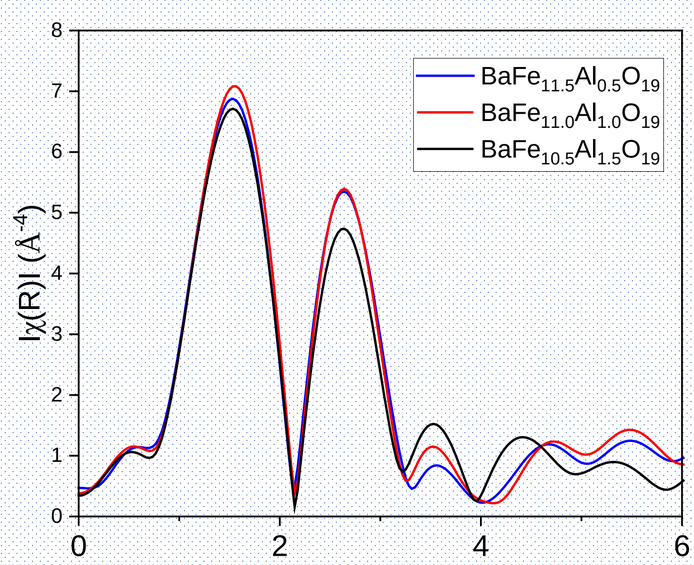
Lattice constants determined from the X-ray Diffraction patterns are plotted as a function of the molar quantity of Al^{3+} in unit formula of BaM.

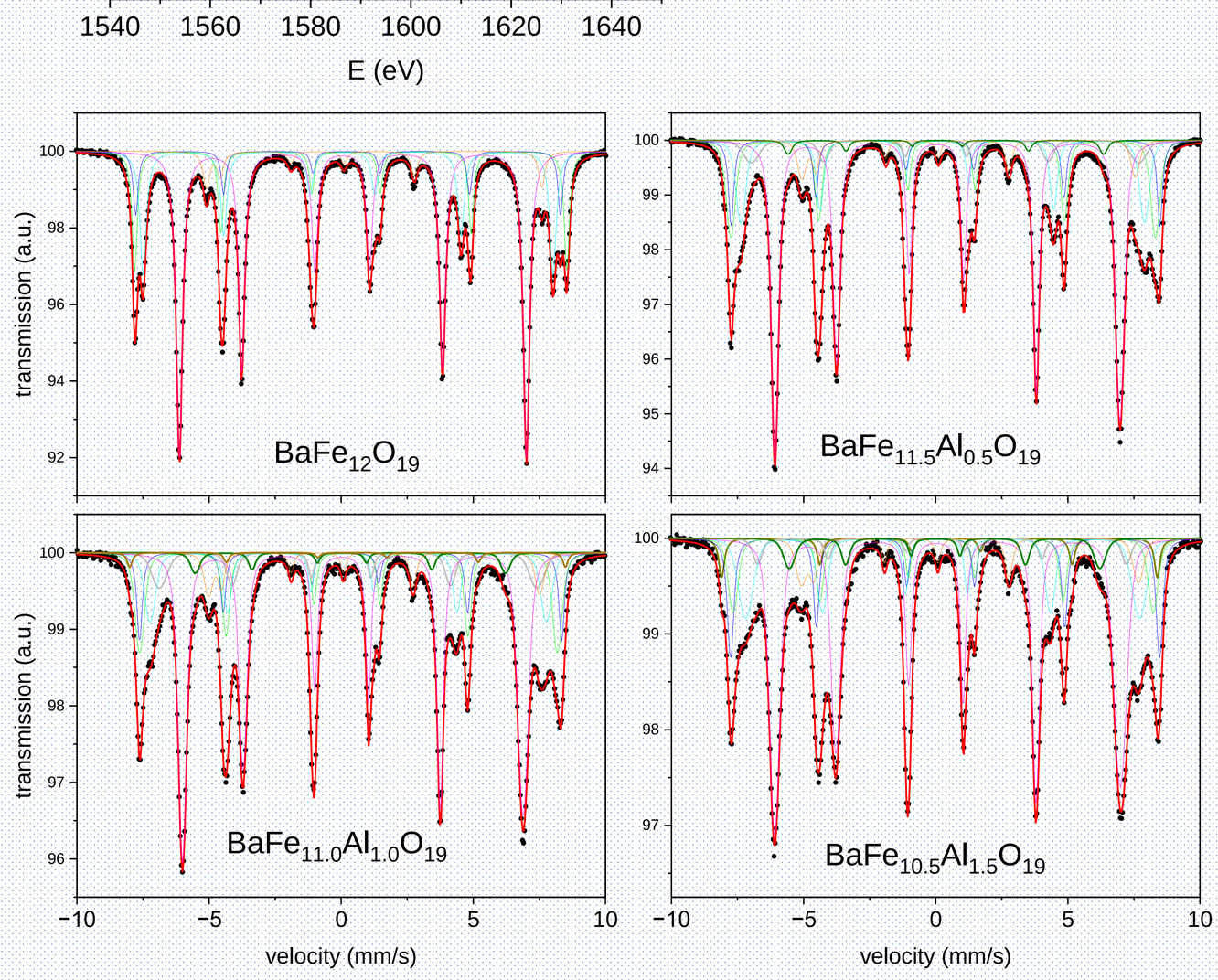


Based on comparison with systematic studies of Al K-edge XAS in mineral samples, we conclude that the spectral features observed are fingerprints of predominantly six-fold coordinated Al site.



XAS studies suggest that Al^{3+} ions in all the doped samples have essentially the same octahedral environment and thus confirm that aluminum ions enter the lattice of BaM.

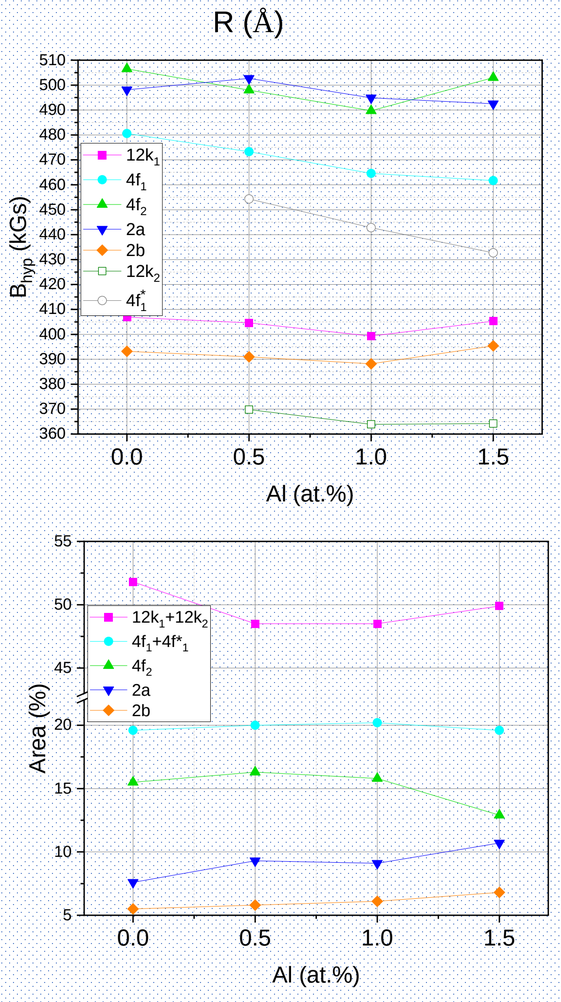


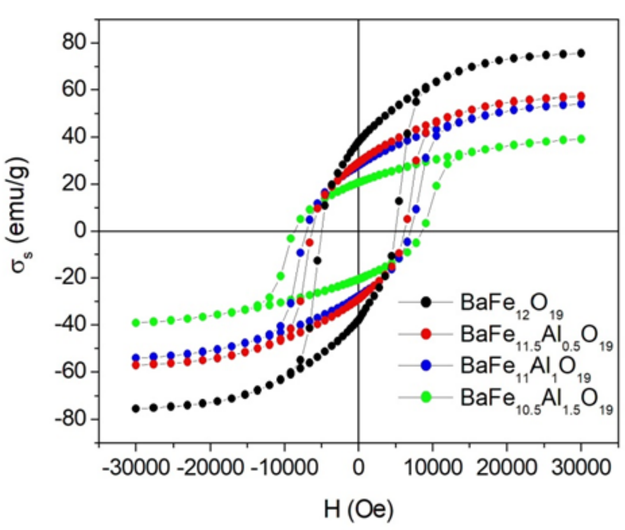


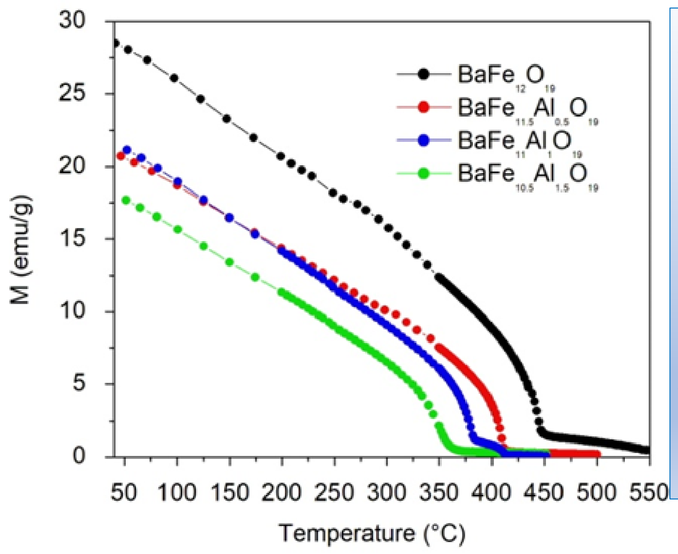
For the doped samples, the site-component 12k- and 4f1 is split into two.

The substitution of iron ions for aluminum ions in the BaM hexaferrite occurs predominantly in the 12k, 2a and/or 4f2 positions. Remarkably, all they are the octahedral sites.

The decrease in hyperfine field at the 2a and 4f1 and 4f1* sites had more weight in the magnetization than the increase at the other sites.







Both temperature and field dependent magnetization profiles indicate a gradual change in the magnetic order of Fe magnetic ions in the hexaferrite studied due to the partial replacement of Fe^{3+} ions by Al^{3+} ions.

It was verified that for all the levels of doping with aluminum, a successful substitution of Fe^{3+} for Al^{3+} took place in the lattice of the host. It was concluded that the substitution occurred predominantly in octahedral crystallographic positions. The Curie temperature value decreased approximately 30 °C for every 0.5 at.%. of aluminum doping.

Acknowledgments

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