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Immobilisation of Phenanthroline-bis Triazine (C1-BTPhen) on Magnetic Nanoparticles for Co-extraction of Americium(III) and Europium(III)

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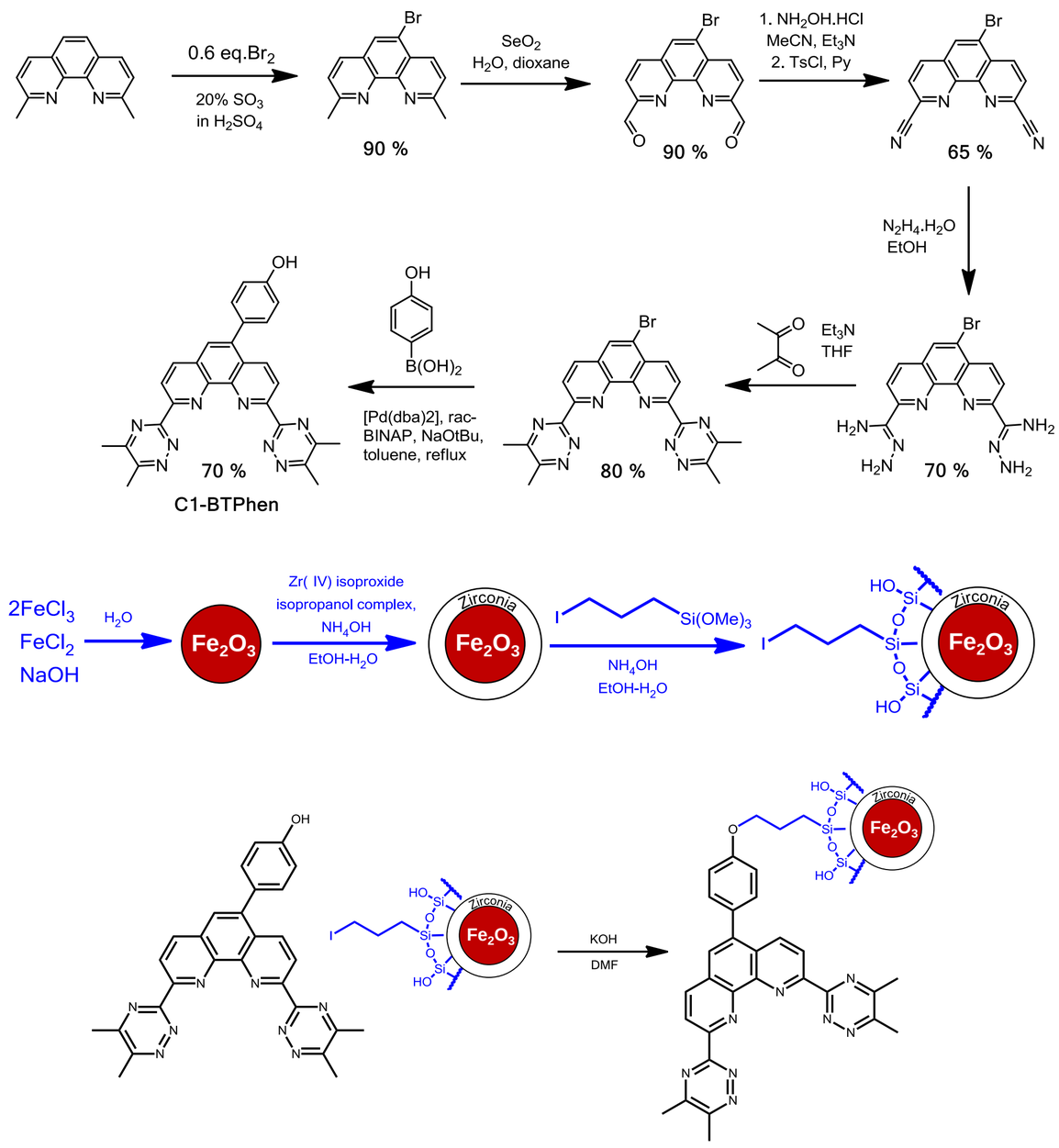
Introduction

Magnetic iron oxide nanoparticles (MNPs) have attracted much interest over recent years because of their large surface area and magnetic properties, meaning they can be extracted from solution by the application of an external magnetic field.

Iron oxide MNPs can be modified with a surface coating of silica or zirconia in order to reduce aggregation and provide a means of attachment of additional functionality. The particle surface can thus be modified with ligands that have an affinity for metal ions.

In this work, iron oxide MNPs were coated with zirconia and functionalized with C1-BTPhen to create a dispersible sorbent that can be magnetically collected to investigate its ability to extract An(III) and Ln(III).

Synthesis



Scheme 1: Synthesis of C1-BTPhen functionalized Fe_2O_3 MNPs .

Results

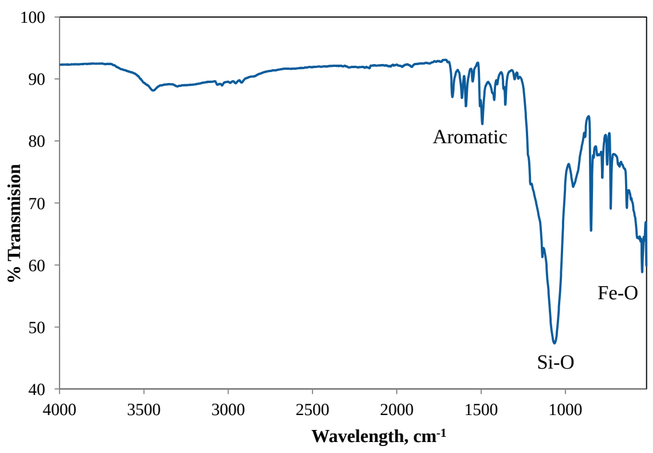
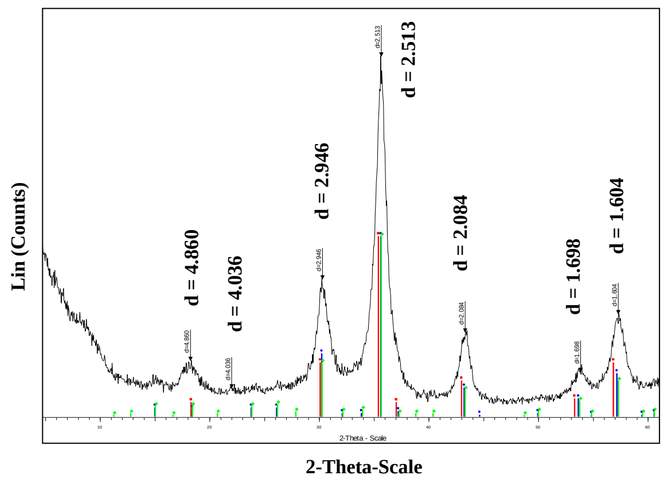


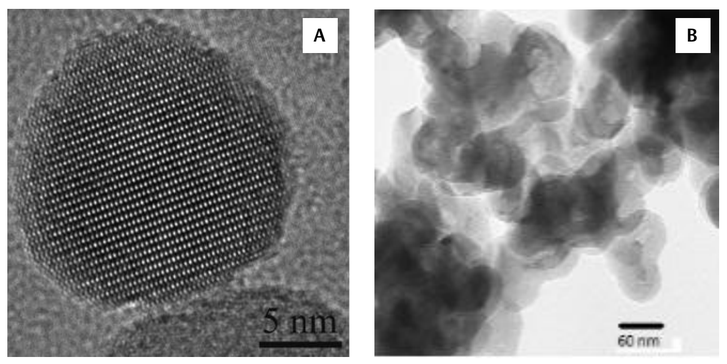
Figure 1: FR-IR spectrum of C1-BTPhen functionalized Fe_2O_3 MNPs.

- Band at 580 cm^{-1} is characteristic of the Fe-O vibrations related to the Fe_2O_3 (maghemite core).
- Band at 1080 cm^{-1} owing to Si-O stretching.
- Bands at 1500-1600 cm^{-1} owing to C=C aromatic vibrations confirming the presence of C1-BTPhen.



- XRD spectrum of MNPs shows the presence of Fe_2O_3 as maghemite.

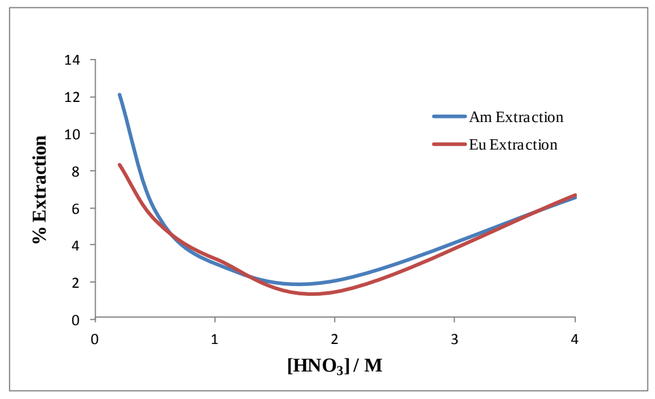
Figure 2: X-ray powder diffraction pattern of Fe_2O_3 MNPs.



- TEM image of **(A)** shows the Fe_2O_3 MNPs have an average size of 15nm.
- TEM image of **(B)** demonstrates the presence of a zirconia shell with an average diameter of 60 nm.

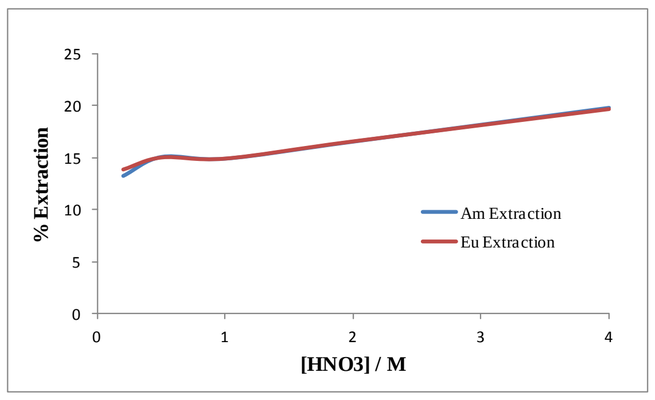
Figure 3: TEM images of (A) Fe_2O_3 MNPs and (B) Fe_2O_3@ ZrO_2 MNPs.

Extraction Studies



- Suspensions of the C1-BTPhen functionalized Fe_2O_3 MNPs in octanol were contacted with nitric acid solutions containing ^{241}Am and ^{152}Eu radiotracers.
- No extraction was shown by Fe_2O_3@ ZrO_2 MNPs (Figure 4).
- 15-20% extraction was observed for C1-BTPhen functionalized Fe_2O_3 MNPs (Figure 5).

Figure 4: % Extraction of Am(III) and Eu(III) by Fe_2O_3@ ZrO_2 MNPs in octanol as a function of $[HNO_3]$.



Lack of selectivity is possibly due to the inability of C1-BTPhen to form a 2:1 complex with Am(III). Studies continue with longer linkers connecting BTPhen derivatives to MNPs.

Figure 5: % Extraction of Am(III) and Eu(III) by C1-BTPhen functionalized Fe_2O_3 MNPs in octanol as a function of $[HNO_3]$.

Conclusions

In summary, we have prepared C1-BTPhen-MNPs, the first example of immobilisation of BTPhen ligand on to the solid support. These MNPs exhibited some affinity for both Am(III) and Eu(III) and successfully extracted 20% of both cations from 4M HNO_3 solutions in which the MNPs were stable. These findings may lead to the development of various BTPhen ligands onto the solid support and may provide a potential platform for developing a new route for lanthanides/actinides extraction from nuclear waste.

References

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