

POLYOXOMETALATE-BASED PARAMAGNETIC MRI CONTRAST AGENTS

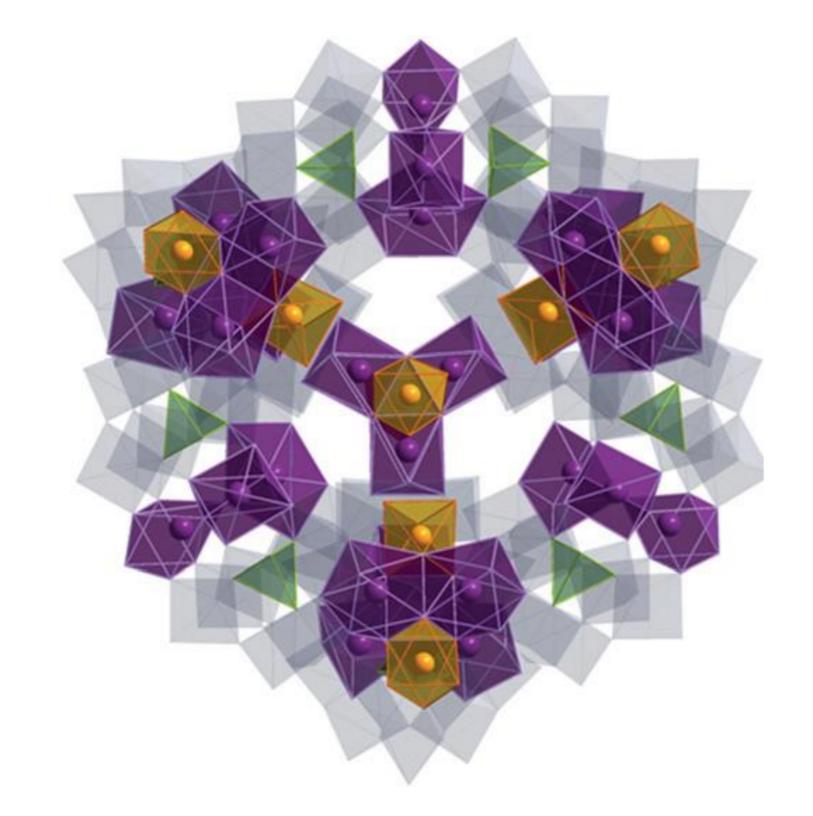
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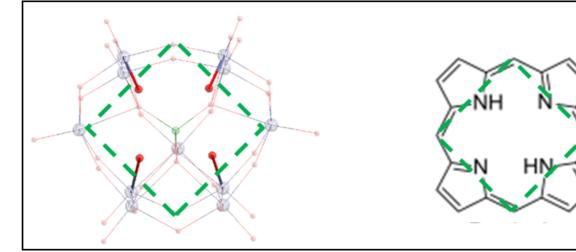
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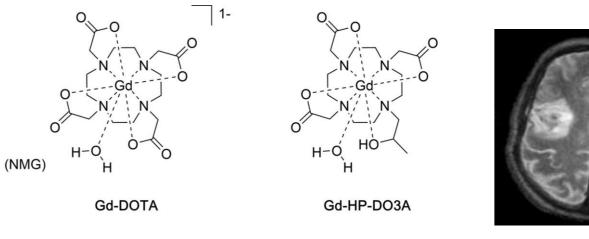
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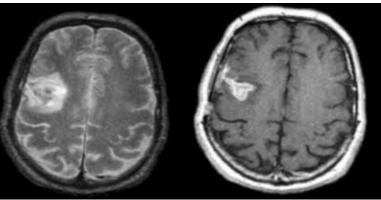
POM-Based MRI Contrast Agents (CAs)

Polyoxometalates (POMs) are anionic clusters composed of early transition metal-oxygen clusters. When integrated with 3d,4f or combined 3d-4f metals at lacunary sites they yield diverse molecular structures with unique electronic properties. These properties play a crucial role in catalysis, magnetism and material science. Paramagnetic metal containing polyoxometalates serves as an inorganic analogue of MRI contrast agents, intended for non-human applications. Their efficacy is evaluated using Nuclear Magnetic Resonance(NMR) technique, measuring their ability to enhance longitudinal and transverse relaxation of nearby water molecules, known as Paramagnetic Resonance Enhancement (PRE)¹⁻².





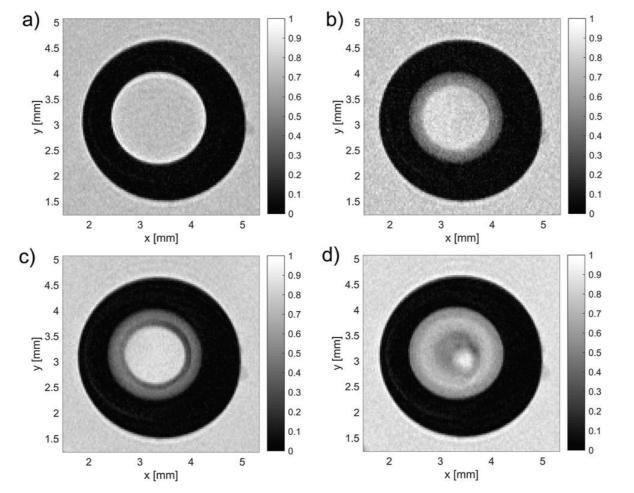




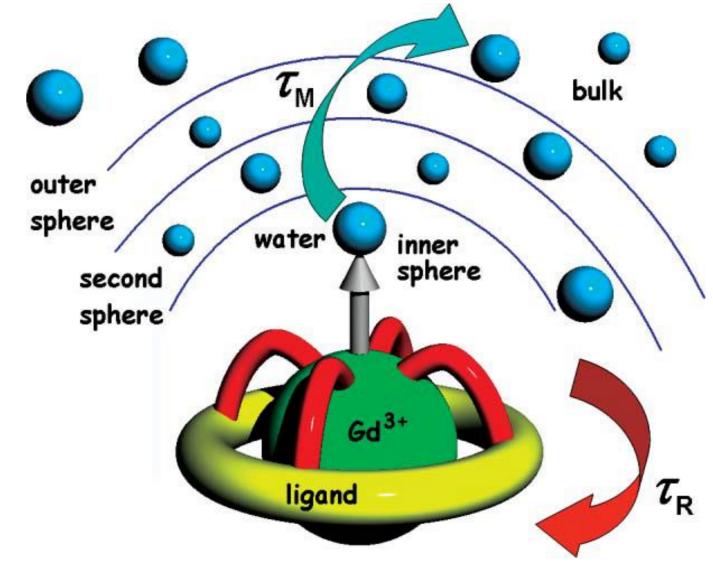
Structures of commercially approved clinical MRI contrast agents, MR image of brain before and after CAs; DOI: 10.1021/acs.chemrev.8b00363

 $[\{(GeW_9O_{34})_2RE^{III}_3(OH)_3(H_2O)\}_6\{Co^{II}_2RE^{III}_3(OH_2)_6(OH_2)_6\}_4]^{56-} \{RE_{30}Co_8\} \\ RE = Dy, Gd, Eu, Y; WO_6 \text{ octahedra gray, } GeO_4 \text{ tetrahedra green, } CoO_6 \\ \text{ orange, } DyO_x \text{ purple }; (DOI: 10.1002/anie.201504663)$

Analogy of monolacunary POM ligand [GeW₁₁O₃₉]⁸⁻ with porphyrin



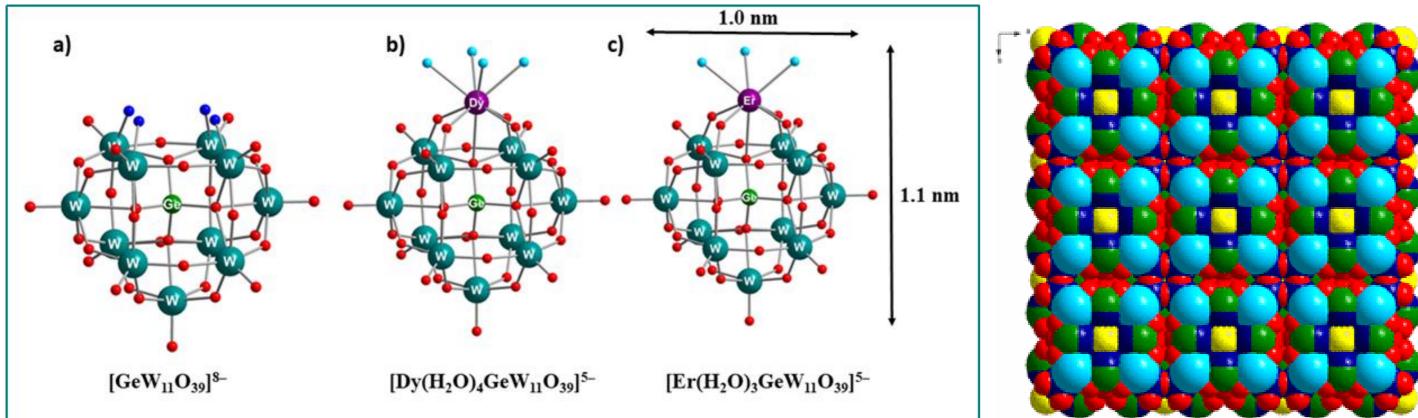
Axial MR image during an in situ dead end membrane filtration of skimmed milk ($Gd_{30}Co_8$ added to enhance the MRI Contrast)

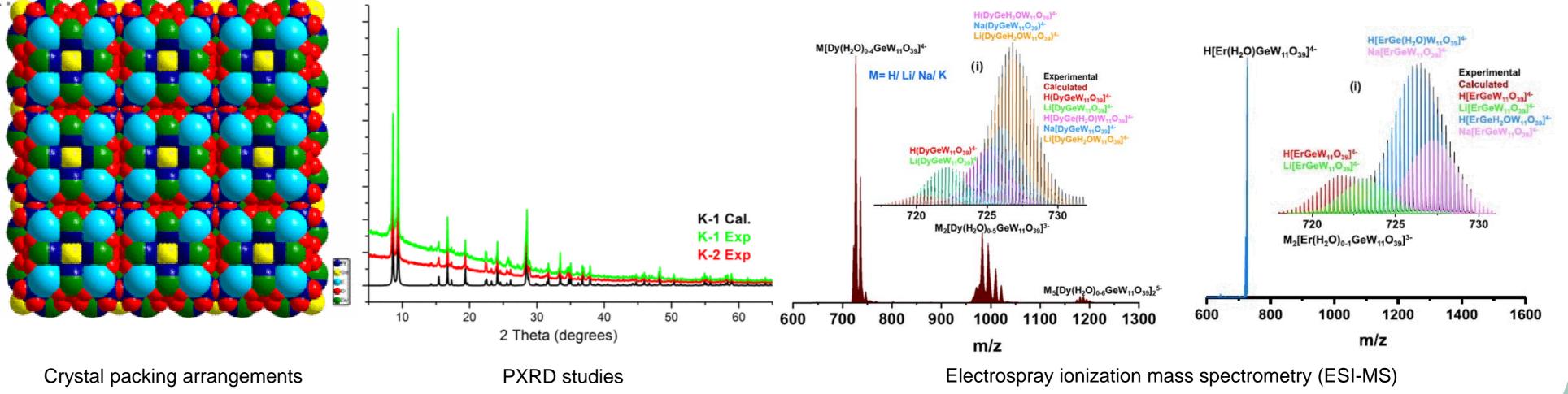


Representation of CAs in solution; DOI: 10.1039/b719704g

Mononuclear Potential MRI Contrast Agents

Two monolanthanide-containing polyanions based on monolacunary Keggin germanotungstates $[Ln(H_2O)_n GeW_{11}O_{39}]^{5-}$ (Ln = Dy, Er, *n* = 4,3) have been synthesized in simple one-pot synthetic procedure and compositionally characterized in solid state by single-crystal X-ray diffraction, powder X-ray diffraction, Fourier transform infrared spectroscopy, thermogravimetric analysis, and elemental analysis.

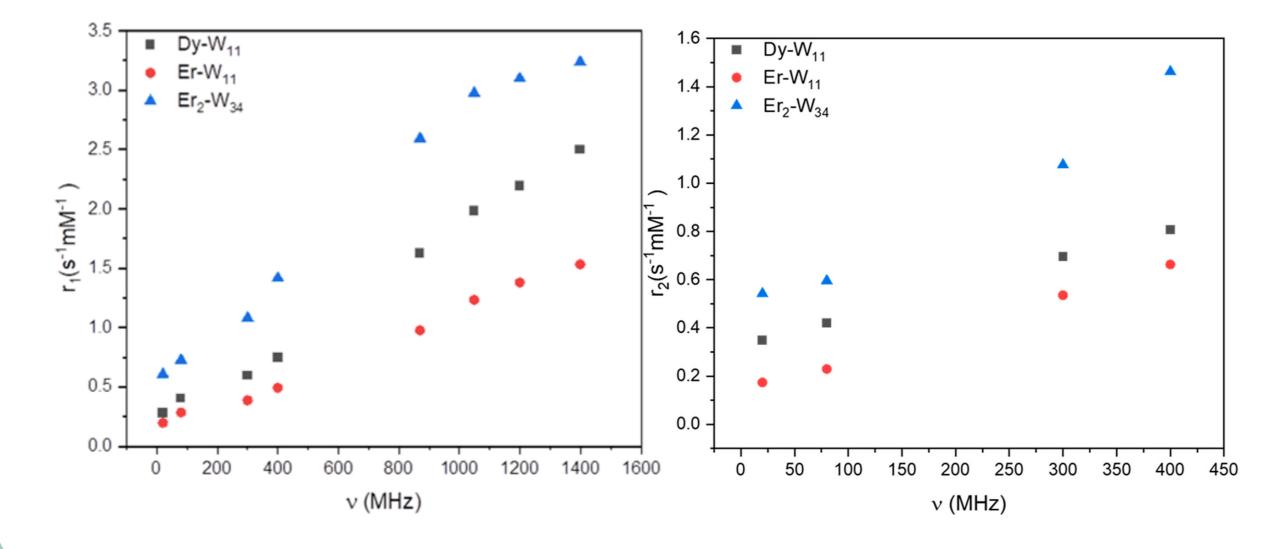




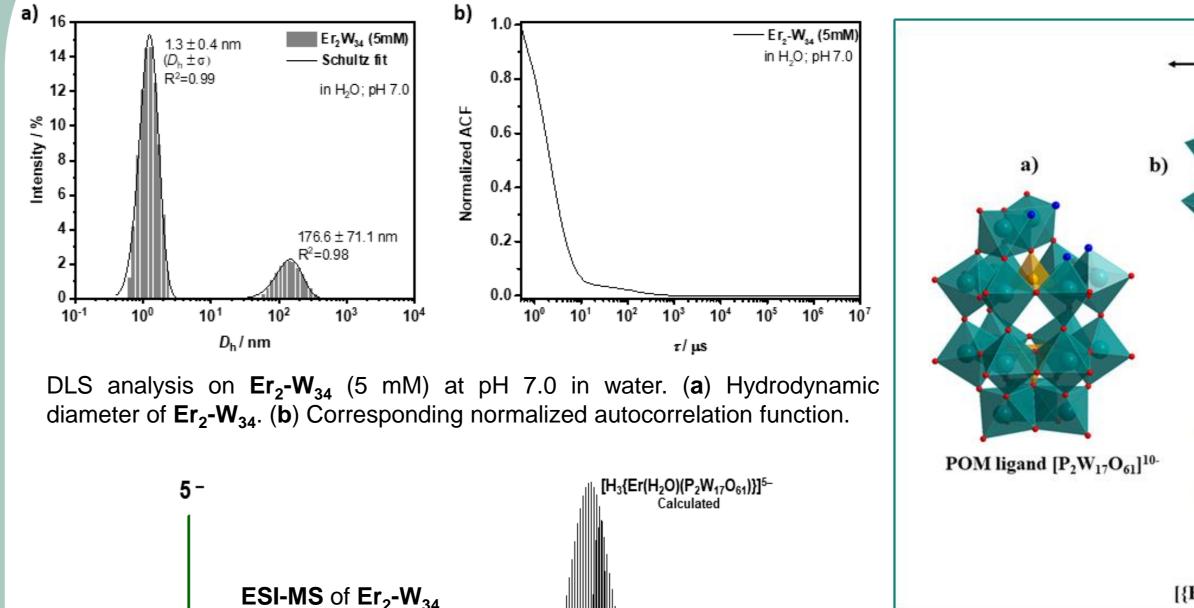
Ball and stick representation of (a) Keggin POM ligand (b) (Dy- W_{11}), (c) (Er- W_{11}) Colour code: O= Red, Aqua= Turquoise, Four oxoligands that coordinate to paramagnetic metal ions = Dark blue

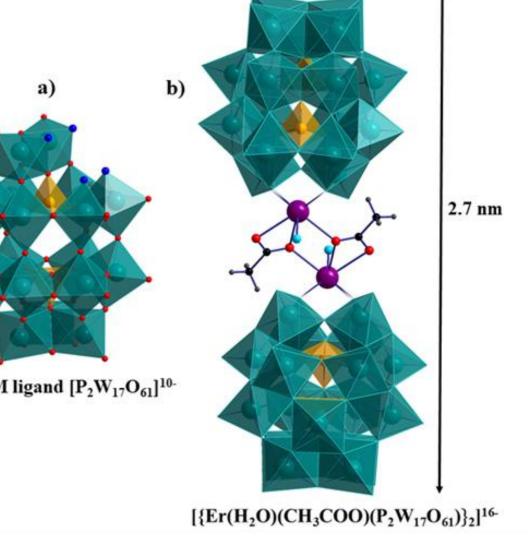
Water ¹H Relaxation Measurements

To investigate the Paramagnetic Relaxation Enhancement (PRE) of the POMs $(Dy-W_{11})$, $(Er-W_{11})$ and (Er_2-W_{34}) , longitudinal and transverse relaxivity measurements were performed at NMR Larmor frequencies from 20 MHz to 1.4 GHz.



Dinuclear Potential MRI Contrast Agents

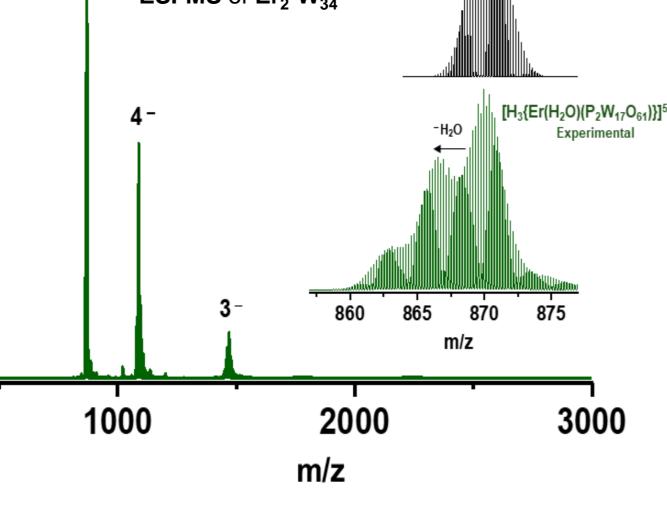




longitudinal relaxivities r_1 and transverse relaxivities r_2 of ¹H of water with POM metal clusters (**Dy-W**₁₁ and **Er-W**₁₁, and **Er₂-W**₃₄) as a function of the Larmor frequency *v*

Conclusion

The high anisotropic electronic ground state of the paramagnetic lanthanide ions in the molecules provides very short electronic relaxation times in the ¹H relaxation measurements so it can perform as an efficient MRI CAs at intermediate to ultra-high magnetic fields.



(a) Ligand (b) Er_2 - W_{11} . Color code : O= red; aqua ligand = turquoise, four oxo ligands that coordinate to Er metal ions = dark blue, WO₆ octahedral =teal, PO₄ tetrahedra = yellow, Er =violet, C = black, H = grey.

A dinuclear erbium(III) substituted sandwich-type POM (Er_2 - W_{34}) has been isolated from a simple one-pot synthetic procedure and characterized it in the solid as well as in the solution state.

(1) Venu, A.C, Molecule, 2020, 26(24) 7481. (2) Ibrahim M, Molecule, 2020, 25, 4229. (3) Ibrahim M, Dalton trans, 2019, 48, 15597-15604. (4) Ibrahim M, ACS Omega, 2019, 4, 21873-21882

KIT – University of the State of Baden-Wuerttemberg and National Research Center of the Helmholtz Association

