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# Self-assembly of Gd<sup>3+</sup>-bound keplerate polyanions into nanoparticles as a route for the synthesis of positive MRI contrast agents. Impact of the structure on the magnetic relaxivity

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## Abstract

© The Royal Society of Chemistry. The present work introduces Gd<sup>3+</sup> complexes with giant keplerate polyanions as a promising basis for MRI contrast agents. The impact of Gd<sup>3+</sup> binding with different building blocks of keplerates on the magnetic relaxivity of the complexes is revealed by comparative study of the keplerates [ $\text{Mo}_6\text{O}_{21}\text{Mo}_2\text{O}_4(\text{OAc})_3$ ]<sup>42-</sup>, [ $\text{Mo}_6\text{O}_{21}\text{Mo}_2\text{O}_4(\text{HPO}_4)_3$ ]<sup>72-</sup>, and [ $\text{Mo}_6\text{O}_{21}\text{Mo}_2\text{O}_2\text{S}_2(\text{OAc})_3$ ]<sup>42-</sup>. Unprecedentedly high longitudinal and transverse relaxivity values (up to 250 and 300 mM<sup>-1</sup> s<sup>-1</sup> correspondingly) are achieved for the keplerates possessing edl{Mo<sub>2</sub>O<sub>4</sub>(OAc)} and {Mo<sub>2</sub>O<sub>4</sub>(HPO<sub>4</sub><sup>2-</sup>)} moieties under their 1 : 1 complex formation with Gd<sup>3+</sup>. The transformation of the external pores from Mo<sub>9</sub>O<sub>9</sub> to Mo<sub>9</sub>O<sub>6</sub>S<sub>3</sub> in the {Mo<sub>2</sub>O<sub>2</sub>S<sub>2</sub>(OAc)}-keplerate and an increase in the Gd<sup>3+</sup>-to-keplerate ratio are the factors that decrease the relaxivity. The rapid degradation of the free keplerates in aqueous solutions restricts the use of the Gd<sup>3+</sup>-bound keplerates with 1 : 1 stoichiometry as MRI contrast agents. In this work, the optimized stoichiometry of the complexes, their self-assembly into ultra-small nanoparticles and their hydrophilic coating by a triblock copolymer are highlighted as tools for increasing both the colloid and chemical stability of the keplerate complexes. Optimal keplerate compositions have been identified to achieve a compromise of low cytotoxicity and high stability; these Gd<sup>3+</sup>-bound keplerates exhibit longitudinal and transverse relaxivity values (95 and 114 mM<sup>-1</sup> s<sup>-1</sup>, respectively), well within the region of interest for MRI techniques.

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