

European Network on NMR Relaxometry

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Contrast by quadrupole enhanced relaxation (CONQUER): A concept for novel smart MRI contrast agents

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Introduction: CONQUER aims at the development of completely novel MRI contrast agents (CAs) based on relaxation enhancement of water protons by quadrupolar nuclei (QN) with high spin quantum number (especially $I=9/2$). One central feature of quadrupole relaxation enhancement (QRE) is its expected strongly frequency-selective effectivity. This opens a wide range of possibilities to functionalise QN-carrying nanoparticles (NP) in terms of 'smart' action. QRE could e.g. be activated or inactivated by external (i. e. a magnetic field) or internal signals (i. e. binding to specific sites or changes of the particle rotation by pathophysiological processes).

Methods and results: The project focuses especially on CAs composed of ^{209}Bi -Aryl-compounds grafted onto biocompatible nanoparticles based on polysaccharides. As a theoretical basis for the development of the compounds, relaxation models based on combined perturbation- and stochastic Liouville theories have been developed for systems containing QN with $I=9/2$. They were used for predicting the relaxation dispersion profiles of candidate compounds as functions of the following parameters: quadrupole coupling constant, anisotropy factor and magnetogyric ratio of the QN, the distance between ^1H and the QN as well as the dynamics of the CA and the ^1H carrying molecules and the water exchange rate. Several promising ^{209}Bi -Aryl-compounds were synthesized and fully characterized concerning their chemical structure, purity and crystals structure. Most of them show NQR transition frequencies close to the Larmor-Frequency of protons at clinical field strengths (3T). The results demonstrate that the tuning of the optimum frequency for QRE is feasible by attaching appropriate ligands to the aryl rings. Moreover first NMRD profiles confirm the presence of QRE in some of the the solid compounds. In addition dedicated small animal-scanning hardware for FFC-MRI in a clinical 3-T scanner has been implemented so as to have the tools for evaluating the new compounds in future MRI experiments. The current research focuses on the development and characterization of NPs carrying these Bi-Aryl compounds and their NMRD characterization in solution.

Discussion: The multidisciplinary nature of the project requires the combination of the expertise of quantum physics, chemical and biomedical engineering, material characterization as well as nanotoxicology. The presentation will give an overview of the so far achieved results of CONQUER. Moreover it will help to identify the potential for future cooperations inside EURELAX which go beyond the already existing collaboration with EURELAX members.