Hyperpolarized Metabolic and Molecular Imaging for Early-stage Cancer Diagnosis

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Magnetic resonance (MR) research is one of the most important analytical tools for chemistry and biological study. It provides not only detailed information on the structure of small molecules and macromolecules, but also on molecular interactions. Because of the inherent low sensitivity of MR, which stems from a small Zeeman splitting of the nuclear spin energy states, a long signal averaging time or a high spin concentration is often required. A variety of methods have been explored to improve the sensitivity of MR. Especially, large signal gains can be obtained by hyperpolarization of the nuclear spins. MR signals of hyperpolarized samples are enhanced by several orders of magnitude when compared to the signals from thermal polarization. Dissolution Dynamic Nuclear Polarization (D-DNP) is a versatile technique capable of polarizing many different nuclei in the solid state at low temperature, and subsequently providing a hyperpolarized liquid sample following a dissolution step. The resulting signal enhancement has made it possible to obtain detailed information in research fields as varied as metabolic imaging or enzyme catalysis. This research aims to extend the applicability of dissolution DNP into new areas of chemistry and biology, which involve studying protein-ligand interactions, real-time kinetic and mechanistic studies for enzyme catalyzed and polymerization reactions, and ^{13}C metabolic imaging for early-stage cancer detection.