Heterogeneous catalysis of NMR Signal Amplification by Reversible Exchange (SABRE)

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Summary

Vanderbilt researchers have developed heterogeneous catalysis and catalyst for the NMR Signal Amplification by Reversible Exchange (SABRE) hyperpolarization process. Coupled with the researchers' development of a method to perform SABRE in aqueous solutions, this discovery could allow fully biocompatible SABRE hyperpolarization processes in water with catalyst recycling. This would allow the production of pure aqueous contrast agents requiring only parahydrogen as a consumable.

Addressed Need

Hyperpolarization of nuclear spin ensembles has increased NMR and MRI sensitivities >10,000. This has enabled the detection of metabolism in biological tissue through the imaging of injected hyperpolarized organic molecules. The two main hyperpolarization techniques available are Dynamic Nuclear Polarization (DNP) and Parahydrogen Induced Polarization (PHIP). Of these techniques, PHIP requires less instrumentation, is lower in cost, and has a higher throughput. One emerging PHIP technique known as SABRE, allows the hyperpolarization of small molecules using parahydrogen without modification to the contrast agent. The SABRE method uses a catalyst, such as Iridium (Ir) complexes, to enable the exchange of a substrate and parahydrogen in solution. Until this discovery, the SABRE method used only homogeneous catalysts in organic solvents. This invention combined with a previous invention potentially allows SABRE hyperpolarization to be performed with heterogeneous catalyst in aqueous media which allows for a biocompatible SABRE hyperpolarization process with the ability to recycle the catalyst.

Technology Description

This invention involves the synthesis of novel Ir-based catalysts to substrate NMR signal in a heterogeneous (HET) phase by covalently tethering to polymer microbeads. This produces heterogeneous SABRE (HET-SABRE) catalyst particles which when combined the substrate and exposed to parahyrogen gas, yields a 5-fold enhancement was in observed in ^{1}H NMR spectra following sample transfer in high field (9.4T). Larger enhancements were observed replacing the polymer microbeads with TiO_2 nanoparticles. There is also a potential for even greater enhancements achievable via further optimization of catalyst structure and hyperpolarization process conditions.

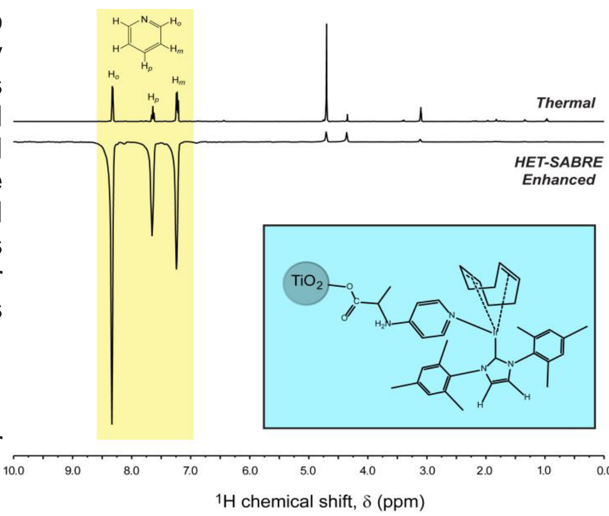

Fig. 1. (top) ^{1}H NMR spectrum from a mixture containing d4-methanol solvent, HET-SABRE catalyst particles, and the pyridine substrate thermally polarized at 9.4T. (b) corresponding HET-SABRE spectrum after pH2 administration. Inset shows the chemical structure of the HET-SABRE Ir-based catalyst tethered covalently to $Ti0_2$ nanoparticles.

Advantages

- Minimal instrumentation and low cost compared to Dynamic Nuclear Polarization (DNP) techniques
- Very fast hyperpolarization speeds of <1 min
- Unlike conventional PHIP techniques SABRE does not require chemical alteration of the substrate
- Combined with SABRE hyperpolarization in aqueous solutions, potentially allows for a biocompatible SABRE hyperpolarization process in water with the ability to recycle the catalyst

Intellectual Property Status

A US provisional patent has been filed.

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Link to Vanderbilt technologies available for licensing