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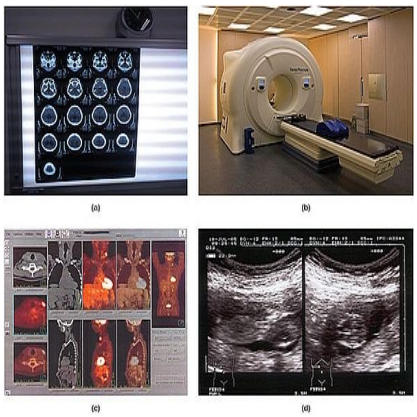
New Hyperpolarisation Agents: Sharper Images, Safer Patients



A team of scientists from French and Swiss research centres have developed a new generation of hyperpolarisation agents that can be used to enhance the signal intensity of imaged body tissues without causing harm to the patient. Their work has been published in *PNAS*, the official journal of the United States National Academy of Sciences (NAS).

Data show that the use of imaging techniques such as CT (computerised tomography), MRI (magnetic resonance imaging), and NMR (nuclear magnetic resonance) has increased sharply over the last two decades. However, persisting problems of image resolution and quality still limit these techniques because of the nature of living tissue. A solution to the problem is hyperpolarisation, which involves injecting the patient with substances that can increase imaging quality by following the distribution and fate of specific molecules in the body. This method though can be harmful or potentially toxic to the patient.

The new hyperpolarisation agents, called HYPSOs, were developed by the teams of Christophe Copéret at ETH Zurich and Chloé Thieuleux at CPE-Lyon. The agents are both effective and safe for the patient, the researchers said. The HYPSOs come in the form of a fine, white, porous powder containing the "tracking" molecules to be hyperpolarised. The HYPSO powder consists of mesoporous silica (silicon dioxide), which is the major component of sand and is commonly used in nanotechnology.

The research project included scientists from EPFL (Federal Institute of Technology Lausanne), CNRS (French National Centre for Scientific Research) and ENS (Ecole Normale Superieure de Lyon). The research team was coordinated by Lyndon Emsley, a professor at EPFL and ENS Lyon.

The silica powder used for the HYPSOs consists of particles containing pore channels, and the surface of each pore channel can be evenly covered with molecules known as 'organic radicals'. These radicals are homogeneously distributed and can induce polarisation around them. "Controlling the radical distribution was a 'tour de force' never achieved in the past, which made the HYPSO materials ideal for this application," Copéret noted. The pore channels are then filled with a solution of the "tracking" molecules to be hyperpolarised, which act as markers for the imaging—e.g., pyruvate, which is important in the production of energy in cells.

Researchers used novel instruments and methods developed by Sami Jannin at EPFL for the hyperpolarisation process. The HYPSO sample is hyperpolarised with microwaves in a magnetic field at a very low temperature. The magnetic moments of the atoms are forced to align through a process called "dynamic nuclear polarisation", which transfers the spin energy of the free radicals' electrons to the markers' nuclei. The electronic spin magnetism of the hyperpolarising agent acts on the marker molecule, aligning, or "polarising", the nuclei of its atoms.

Hot water is then used to melt and flush the substrate out of the powder. With the equipment and conditions needed, the process generally takes place in a room adjacent to the imaging facility. The substrate is then ready to be injected through a long tube into the patient inside the medical imaging device. The entire process only lasts about 10 seconds, according to the research team.

Two scans are performed, one with and one without the hyperpolarised agent. When the two images are compared, the team said, it is possible to observe the distribution of the hyperpolarised marker in the patient's body, which, depending on the medical context, can be indicative of disease. For example, accumulation of pyruvate in the prostate could be an early indication of prostate cancer, the research team added.

The team has tested the efficiency of the HYPSOs method on several imaging markers including pyruvate, pure water, fumarate, acetate, and a simple peptide. As the HYPSOs are physically retained during dissolution, the method yields pure solutions of hyperpolarised markers, free of any contaminant. Thus, the protocol is simpler and potentially safer for the patient, the researchers noted.

With the technique's enhanced efficiency on signal quality, the HYPOs will likely be used with a wide range of molecules. As Jannin pointed out: "We have now received queries of scientists from abroad who are eager to boost their research with this new technology. Amongst other plans, we are very excited about testing these materials in vivo."

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