Functional X-nuclei Magnetic Resonance (Reactive Oxygen Species Detection)

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In the realm of preclinical molecular imaging techniques, there has been a notable surge in interest among the biomedical research community in the field of fluorine (19F) magnetic resonance imaging (MRI). This growing interest is primarily driven by the exceptional properties of fluorinated materials [1]. A standout feature of this method is its remarkable specificity, owing to the negligible presence of natural fluorine in the human body. This characteristic empowers the visualization of 'hotspot' signals, valuable for various biomedical applications like monitoring transplanted cells. Additionally, recent introductions of probes for phosphorous 31P MRI [2,3,4], noted for their significant biocompatibility, have further broadened the horizons of X-nuclei MRI applications.

Some X-nuclei MRI probes, constructed with hydrophilic polymers, can facilitate functional imaging. Their responsiveness to physiological conditions allows real-time functional imaging. When combined 31P/19F MR, these probes provide complementary information critical for a comprehensive interpretation of results. We demonstrate a 31P/19F polymer probe designed for detecting reactive oxygen species (ROS), frequently abundant in pathological conditions such as cancer, that exhibits distinct phosphorous resonance frequencies in the presence and absence of ROS. This chemical shift in 31P MR spectra is detectable even under magnetic field strengths comparable to clinical settings.

For precise in vivo localization of the probe, an inert trifluoromethyl group, unresponsive to physiological variations, is integrated into the probe's structure. This facilitates visualization through "hotspot" 19F MR imaging and serves as an on-site reference. This approach represents an innovative paradigm in functional 31P MR, supplementing the traditional anatomical information offered by 1H MRI with insights into tumor physiology.

[1]. D. Jirak, A. Galisova, K. Kolouchova, D. Babuka, M. Hruby, Magn Reson Mater Phy 2019, 32, 173

[2]. N. Ziółkowska, M. Vít, R. Laga, D. Jirák, Sci. Rep. 2022, 12, 2118.

[3]. L. Kracíková, N. Ziółkowska, L. Androvič, I. Klimánková, D. Červený, M. Vít, P. Pompach, R. Konefał, O. Janoušková, M. Hruby, D. Jirák, R. Laga, Macromol. Biosci. 2022, 22, 2100523.

[4]. T. Rheinberger, U. Flögel, O. Koshkina, F.R. Wurm, Commun Chem. 2023 Sep 1;6(1):182

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