

Fluorine-19

Fluorine-19 (^{19}F) for magnetic resonance is a nucleus of great interest. Fluorine is a strong candidate for MR spectroscopy and imaging because ^{19}F , with a spin $\frac{1}{2}$ nucleus and a natural abundance of 100%, has a gyromagnetic ratio close to that of ^1H and a relative sensitivity approximately 85% that of ^1H . With essentially no ^{19}F in the body, there is no background signal. Additionally, the most electronegative of all elements, ^{19}F has a greater range and sensitivity to its environment via chemical shift than hydrogen does.

The following highlights some of the major concepts that will be discussed in the presentation:

- 1) Why is ^{19}F a good nucleus for magnetic resonance?
 - Pros:
 - a) ^{19}F is the natural isotope and ~100% abundant (vs. e.g., ^{18}F)
 - b) Spin $\frac{1}{2}$ nucleus
 - c) High signal nucleus, compared to other (non-hydrogen) nuclei, with gyromagnetic ratio close to that of hydrogen.
 - d) Biologically inert (i.e., perfluorocarbons)
 - Cons:
 - e) Depending on molecule, spectrum can be simple (single resonance peak) to extremely complex.
 - f) In vivo, low concentrations and sparse distribution
- 2) Hardware considerations for ^{19}F
 - a) Transmit / Receive Coil(s)
 - b) Dual tuned vs. single resonance
 - c) Power settings, shimming, etc.
- 3) Pulse sequence considerations for ^{19}F
 - a) Spectroscopy
 - b) Imaging
 - c) Spectroscopic Imaging (aka, chemical shift imaging)
- 4) Various applications of ^{19}F – based agents
 - a) Cell labeling (e.g. stem cells, endothelial progenitor cells)
 - b) In situ oxygen sensing
 - c) Intravascular Agents
 - d) Passive or indirect targeting (e.g., via in vivo microphage uptake and trafficking)
 - e) Active targeting (e.g., to molecular markers of disease)
 - f) Other applications

For Further Reading:

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3. Mason RP, Shukla H, Antich PP. In vivo oxygen tension and temperature: simultaneous determination using ^{19}F NMR spectroscopy of perfluorocarbon. *Magn Reson Med* 1993;29(3):296-302.
4. Bornert P, Norris DG, Koch H, Dreher W, Reichelt H, Leibfritz D. Fast perfluorocarbon imaging using ^{19}F U-FLARE. *Magn Reson Med* 1993;29(2):226-234.
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6. Mason RP, Rodbumrung W, Antich PP. Hexafluorobenzene: a sensitive ^{19}F NMR indicator of tumor oxygenation. *NMR Biomed* 1996;9(3):125-134.
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8. Janjic JM, Ahrens ET. Fluorine-containing nanoemulsions for MRI cell tracking. *Wiley Interdiscip Rev Nanomed Nanobiotechnol* 2009;1(5):492-501.
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10. Keupp J, Rahmer J, Grässlin I, Mazurkewitz PC, Schaeffter T, Lanza GM, Wickline SA, Caruthers SD. Simultaneous dual-nuclei imaging for motion corrected detection and quantification of ^{19}F imaging agents. *Magn Reson Med* 2011;66(4):1116-1122.