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Trial measurement for para-to-orthohydrogen back conversion under the Fe(OH)3 catalyst condition at J-PARC cryogenic moderator system

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In the neutron scattering experiments using MW-class pulsed neutron sources, specific pulse shape characteristics, such as high intensity, narrow pulse width and short tail etc., are required. Such pulsed neutrons are typically generated by moderating spallation neutrons using liquid hydrogen. Liquid hydrogen is known as a unique moderator material for the neutrons. However, there are two distinct states with different nuclear spins of hydrogen molecules: 'orthohydrogen'and 'parahydrogen'. It is essential to maintain the appropriate state of liquid hydrogen molecules for effective neutron moderation.
In low temperature condition, liquid hydrogen molecules undergo a transition from the orthohydrogen to the parahydrogen, achieving a more stable state. The neutron scattering cross section of the parahydrogen drastically decreases significantly to about a hundred times smaller values than those of the orthohydrogen, at neutron energies below 14.5 meV. Therefore, this unique characteristic of parahydrogen neutron scattering cross section is utilized to decelerate neutron effectively. It is important to maintain a significantly high parahydrogen concentration, to obtain good moderator performance.
However, parahydrogen changes into the orthohydrogen due to collisions with the neutrons during the neutron moderating process, which is called as 'para-to-orthohydrogen back conversion'. Previous studies theoretically have predicted that an increase in orthohydrogen concentration caused by the back conversion can strongly impact the pulse shape of the neutrons. Experimental investigation has been recently conducted to measure the increase in orthohydrogen concentration.
In this study, we propose a new experimental method which easily simulates the condition of the pseudo para-to-orthohydrogen back conversion in the J-PARC cryogenic hydrogen moderator system (CMS). Normal hydrogen gas was temporarily introduced to the CMS at a temperature of 20 K and a pressure of 1.5 MPa to attain a desired parahydrogen concentration, exceeding equilibrium concentration by 1%. We evaluated the deterioration of the Fe(OH)3 catalyst performance using a Raman spectroscopy. Details of the proposed experimental method and the obtained results will be explained.

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