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Monte Carlo simulation of a mesitylene based cold moderator system for accelerator-driven compact neutron sources

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The organic compound mesitylene has been proposed as a suitable material for cold neutron generation alongside liquid ortho/para H2 and solid CH4 at cryogenic temperatures because it has a high hydrogen density, enables a safe operation. To investigate the neutron moderation properties of mesitylene and its potential application in the High Brilliance Neutron Source (HBS) project, a mesitylene based cold moderator system was set up in the Big Karl experimental hall at Forschungszentrum Jülich and performed to determine the cold neutron spectrum at different moderator temperatures.

In the experiment, primary neutrons are generated by the Ta(p,xn)W reaction using a pulsed 45 MeV proton beam and further moderated by polyethylene thermal moderator blocks. An extraction channel is built to gain the neutrons from the thermal maximum, and the cold mesitylene is placed in it. The moderator vessel is a cylinder with a diameter of 60 mm and a height of 30 mm. The mesitylene moderator system is cooled from 300 to 22 Kelvin by a cold finger cryocooler in about two hours. and moderates the neutrons to a long wavelength of up to 40 Å. The moderated neutrons were extracted via the flat side of the vessel and measured by TOF using a 7-meter neutron guide and 3He tube detectors in TOF counter mode.

Monte Carlo simulations of this mesitylene based cold moderator system were performed using the MCNP6.1 program package. The geometry for the simulation is converted from the three dimentional CAD model of the experimental setup directly. The neutron spectra at different mesitylene temperatures were calculated with respect to the gain of the cold neutrons compared to a spectrum at room temperature. A broadening and shift of the cold moderator peaks to longer wavelengths with decreasing moderator temperature is observed in both experimental data and simulation results. When the mesitylene temperature decreases from room temperature to 22 Kelvin, the neutron spectrum peak shifts to a longer wavelength. Mesitylene has proven to be a proper moderator material for cryogenic temperatures around 20 K, which offers good performance.