# Synthesis and evaluation of the structural and electrochemical properties of $MoS_2$ anodes for Na-ion batteries.

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One of the prospective material for an anode electrode for sodium ion batteries (SIBs) is $MoS_2$ because of its unique layered structure enhancing ion intercalation/de-intercalation, and the conversion reaction delivering high theoretical capacity.

In this work the $MoS_2$ powders were obtained by two types of synthesis methods. Firstly, $MoS_2$ was synthesized by chemical vapor deposition (CVD) method using gas-tight Swagelok-type containers. Appropriate amounts of $MoO_3$, S and carbon black powders were mixed in Ar-filled glove box, closed in the stainless steel reactor and subjected for high-temperature annealing at 600-700$^0$C. Secondly, the proper amount of the $(NH_4)_6Mo_7O_{24}\cdot 4H_2O$, thiourea and carbon sources were dissolved in water-based solutions and heated up to 230-240$^0$C in the closed autoclave with continuous stirring. The crystal structure and morphology of the materials was verified by means of the XRD and SEM technique. Comprehensive electrochemical studies including EIS measurements, cycling voltammetry and charge/discharge test were performed in $Na/Na^+/MoS_2$ cells.

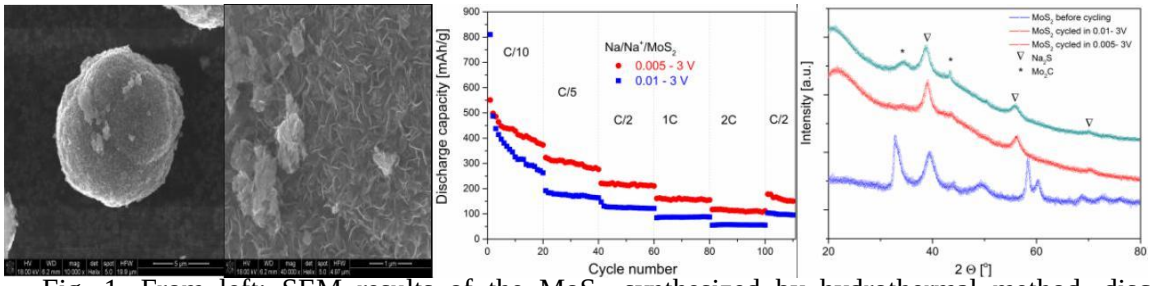


Fig. 1. From left: SEM results of the $MoS_2$ synthesized by hydrothermal method, discharge capacity results for cells with $MoS_2$ obtained by CVD method, XRD results of the fully discharged electrodes after cycling.

The materials synthesized by CVD and hydrothermal methods were single-phased with $MoS_2$ possessing P63/mm hexagonal structure. In case of the $MoS_2$ obtained by CVD, layered agglomerates (1µm) were formed, while $MoS_2$ from hydrothermal procedure possessed round shape agglomerates composed from tiny $MoS_2$ nanoflakes. The modification of the morphology of $MoS_2$ was achieved by changing the solution composition and reaction temperature during hydrothermal reaction. $MoS_2$ materials in $Na/Na^+/MoS_2$ cell exhibited voltage profile indicating ion intercalation mechanism followed by conversion reaction, it was found that the voltage dependence can be modified by changing the morphology and crystalline size of the $MoS_2$ powders. Synthesized materials exhibited discharge capacity around 500 mAh/g during first cycles with C/10 discharge rate. In case of the $MoS_2$ obtained by CVD method it was found that discharge capacity retention depends strictly on the lower voltage cut-off and is connected with the phase composition of the electrode after cycling. The synthesis methods (CVD and hydrothermal) of the $MoS_2$ as an anode material for Na-ion batteries were described. Evaluation of the structural and electrochemical properties of the synthesized materials was carried on.

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