Joint Seminar of UniSysCat and the Institute of Chemistry, TU Berlin

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The development of redox-active conjugated polymers for energy storage and electrocatalysis

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Redox-active conjugated polymers are an interesting class of materials for electrochemical devices since their properties can be tuned by chemical design to enable redox activity in various electrolytes. In my talk, I will introduce design rules for the development of conjugated polymers with high electronic and ionic charge transport properties to enables fast charging of single-phase electrodes in aqueous electrolytes [1,2]. While the choice of the polymer backbone is important for achieving electrochemical stability of the charged polymer states, it is found that the tuning of the local environment of the polymers is equally important. The tuning of the local environment of the materials is achieved by attaching hydrophilic (polar) side chains to the polymer backbone to enable fast ion transport, swelling, and reversible phase changes. Electrodes fabricated with these polymers can utilize more than 70 % of the available redox-active state in the bulk of the polymer while maintaining high electrochemical stability during continuous cycling.

In the second part of my talk, I will show how this concept can be utilized for developing a single-phase, metal-free, and solution processible electrocatalyst for the oxygen reduction reaction in aqueous electrolytes. I will explain the working principle of polymeric electrocatalyst, for which the polymeric organic semiconductor is first activated by an electrochemical doping reaction that increases the reactivity of the material towards molecular oxygen. By employing in-situ spectroelectrochemical measurements and rotating ring disk electrode (RRDE) measurements, the performance of electrocatalyst is evaluated across various pH values where the highest activity is found in alkaline electrolytes. In summary, I will show how the tuning of the polymer's energy levels and side chains is a successful strategy for the development of low-cost, metal-free, and solution-processable electrocatalysts for energy conversion technologies.

[1] A. Giovannitti, C. B. Nielsen, D.-T. Sbircea, S. Inal, M. Donahue, M. R. Niazi, D. A. Hanifi, A. Amassian, G. G. Malliaras, J. Rivnay, I. McCulloch, Nat. Commun. 2016, 7, 13066.

[2] D. Moia, A. Giovannitti, A. A. Szumska, I. P. Maria, E. Rezasoltani, M. Sachs, M. Schnurr, P. R. F. Barnes, I. McCulloch, J. Nelson, Energy Environ. Sci. 2019, 12, 1349.

Prof. Dr. Arne Thomas and Institute of Chemistry, Technische Universität

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