# Predicting ion selectivity of biological and synthetic nanopores by MD simulations and 3D integral equation theory

Leonhard M. Henkes, Florian Mrugalla, Roland Frach, Stefan M. Kast*

*Physikalische Chemie III, TU Dortmund, D-44227 Dortmund, Germany*
*e-mail: leonhard.henkes@tu-dortmund.de*

Several membrane proteins form nanometer-sized pores that act as ion channels in living systems, representing key regulators of essential cellular processes such as homeostasis. Their principle function is to establish a controllable electrostatic potential across the cell membrane by exhibiting highly selective ion conductance. Constructing synthetic analogues of biological pores with designed properties is an important goal in nanotechnology which requires to understand and to control the relevant parameters facilitating selective conductance. As a result, much experimental and theoretical effort is currently spent in attempts to understand design principles.

A computational approach to the design problem has the advantage that control parameters can be systematically varied in a broad range of models, from artificially reduced toy systems up to molecular-scale representations. Here we show that the combination of nonequilibrium molecular dynamics simulations under the influence of an external field in conjunction with the 3D RISM (reference interaction site model) integral equation theory provides consistent data in order to characterize conductance properties and relevant chemical features that control selectivity [1]. We demonstrate results of the integrated approach for a recently described synthetic nanopore that should mimic biological $K^+$ selective ion channels [2].To some extent, the data challenge the experimental interpretation and show that theory can make important contributions to understand nanopore design.

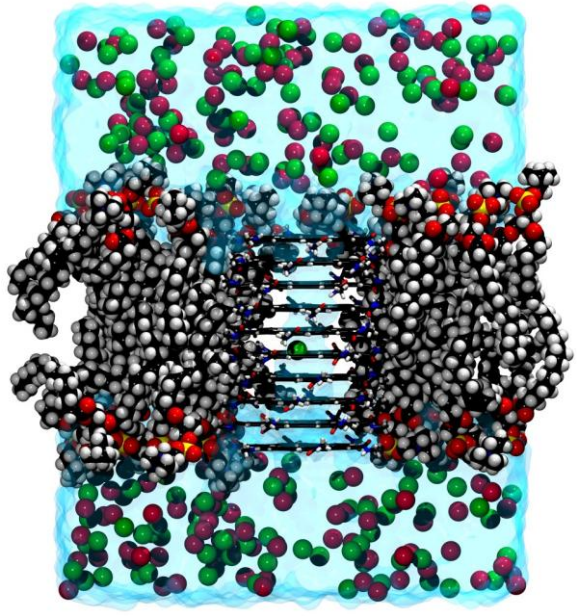

Fig. 1. Simulation snapshot of the synthetic nanopore [2] embedded in a lipid bilayer, solvated by 4 M aqueous KCl solution (green/middle balls: chloride, magenta/dark balls: potassium).

[1] S. M. Kast, T. Kloss, S. Tayefeh, G. Thiel, *J. Gen. Physiol*. **2011**, *138*, 371–373.
[2] X. Zhou et al. , *Nature Commun.* **2012**, *3*, 949.