

Annual Meeting of the DECHEMA/VDI Group Interface-determined Systems and Processes,  
Mixing Processes and Extraction 2026  
Frankfurt, 25/02/2026

# Reactive Mass Transfer in Solvent Extraction: Modelling and Experimental Validation

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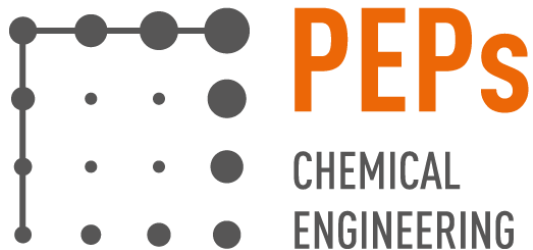
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Products, Environment, and Processes (PEPs)

Department of Chemical Engineering

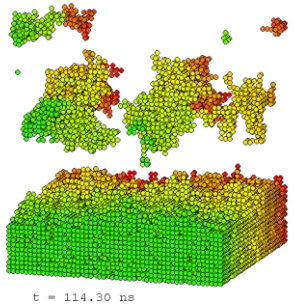
Université de Liège

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# introduction

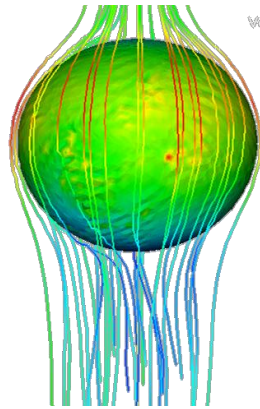
understanding for the fundamentals of mass-transfer kinetics ...



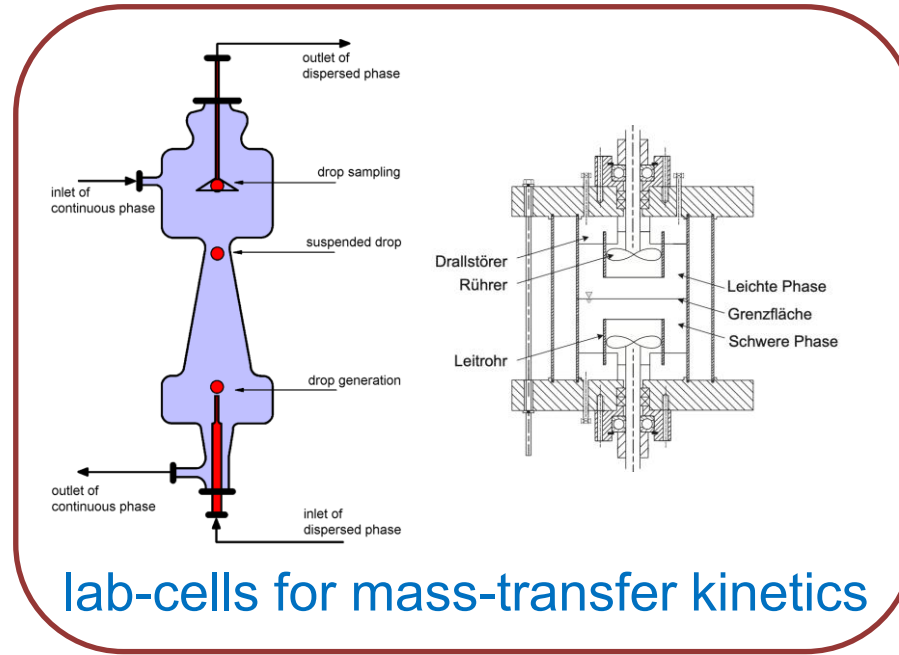
molecules



interfaces



drops



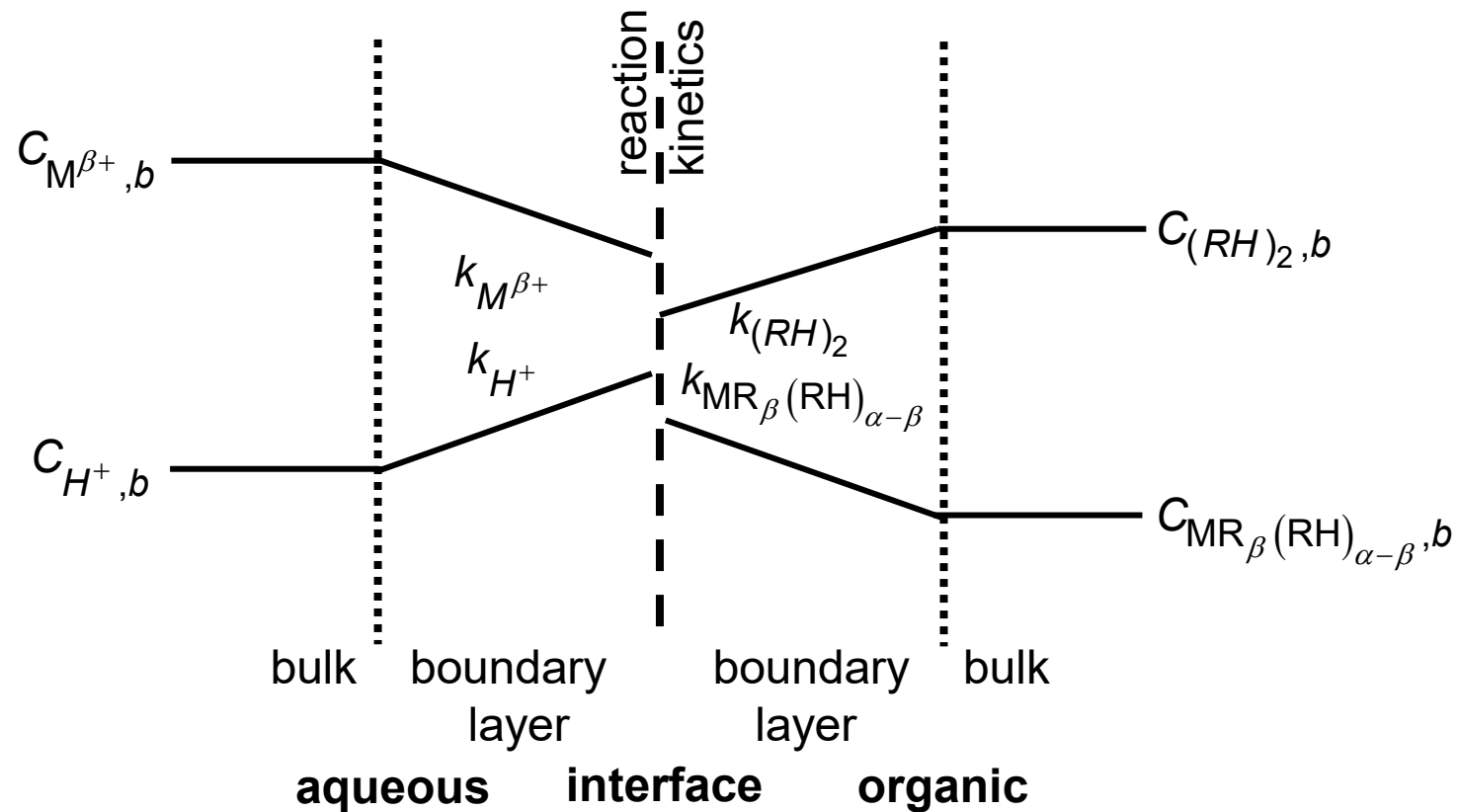
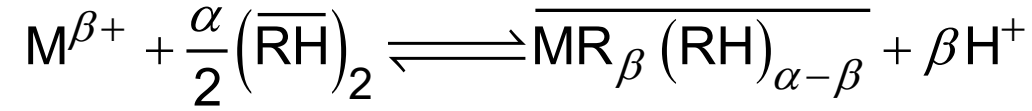
lab-cells for mass-transfer kinetics



extraction column

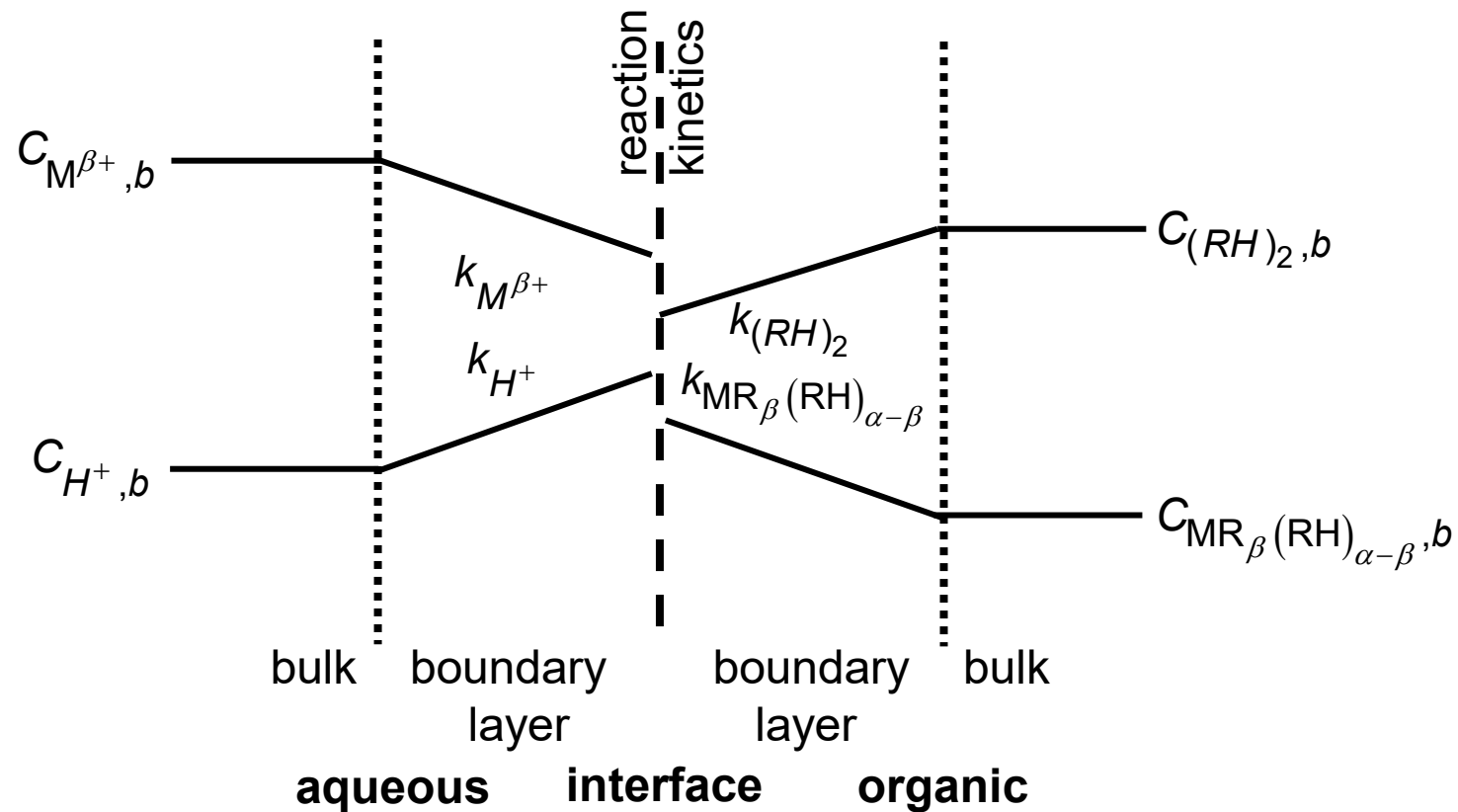
... for the development and scale-up of new extraction processes

# mass-transfer model



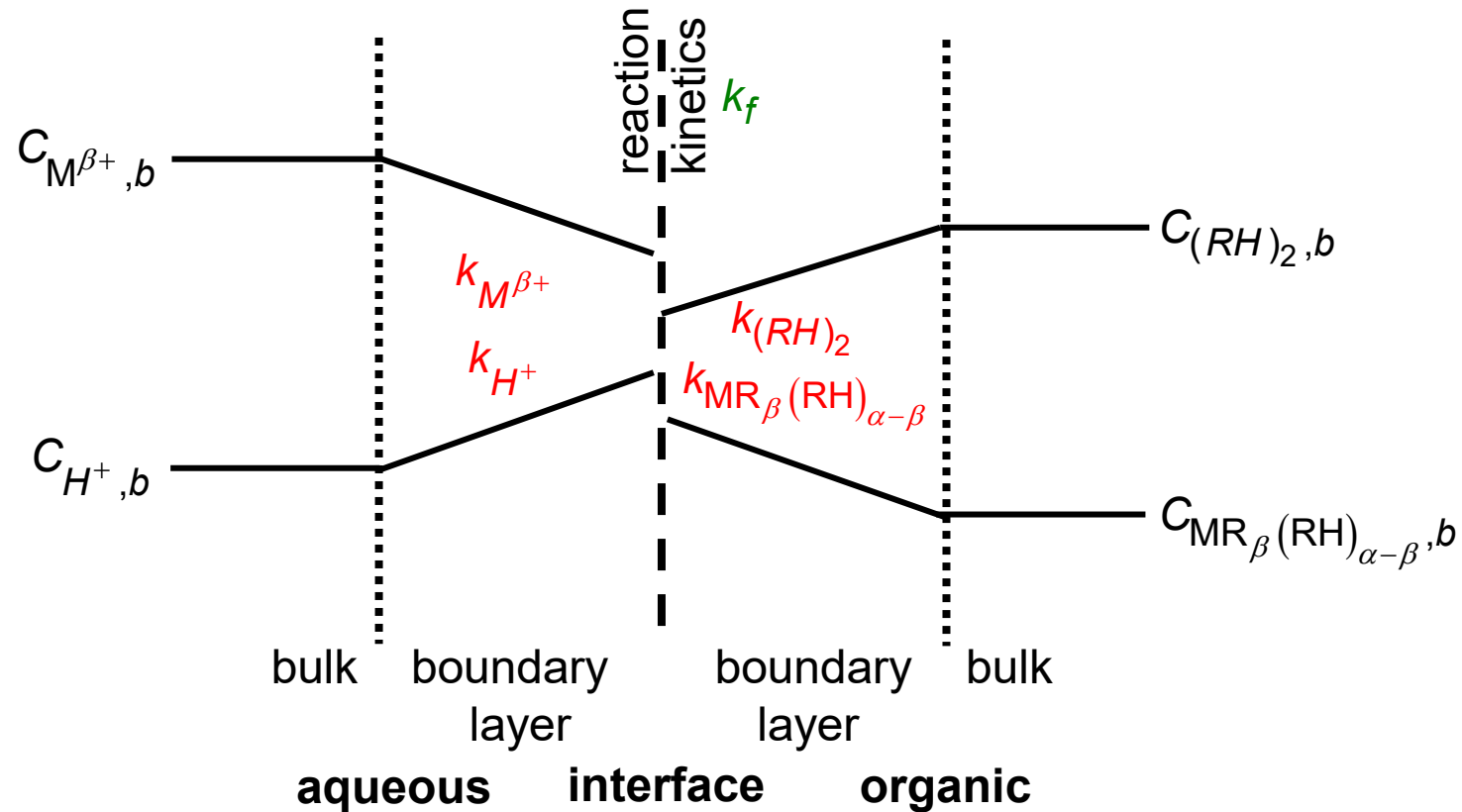
# full mass-transfer model

$$\dot{\xi}'' = k_f \left( \left( C_{M^{\beta+},b} + \frac{v_{M^{\beta+}} \dot{\xi}''}{k_{M^{\beta+}}} \right) \left( C_{(HR)_2,b} + \frac{v_{(HR)_2} \dot{\xi}''}{k_{(HR)_2}} \right)^{-v_{(HR)_2}} - \frac{\left( C_{(MR_\alpha HR)_{\alpha-\beta},b} + \frac{v_{(MR_\alpha HR)_{\alpha-\beta}} \dot{\xi}''}{k_{(MR_\alpha HR)_{\alpha-\beta}}} \right) \left( C_{H^+,b} + \frac{v_{H^+} \dot{\xi}''}{k_{H^+}} \right)^{v_{H^+}}}{K_c} \right)$$



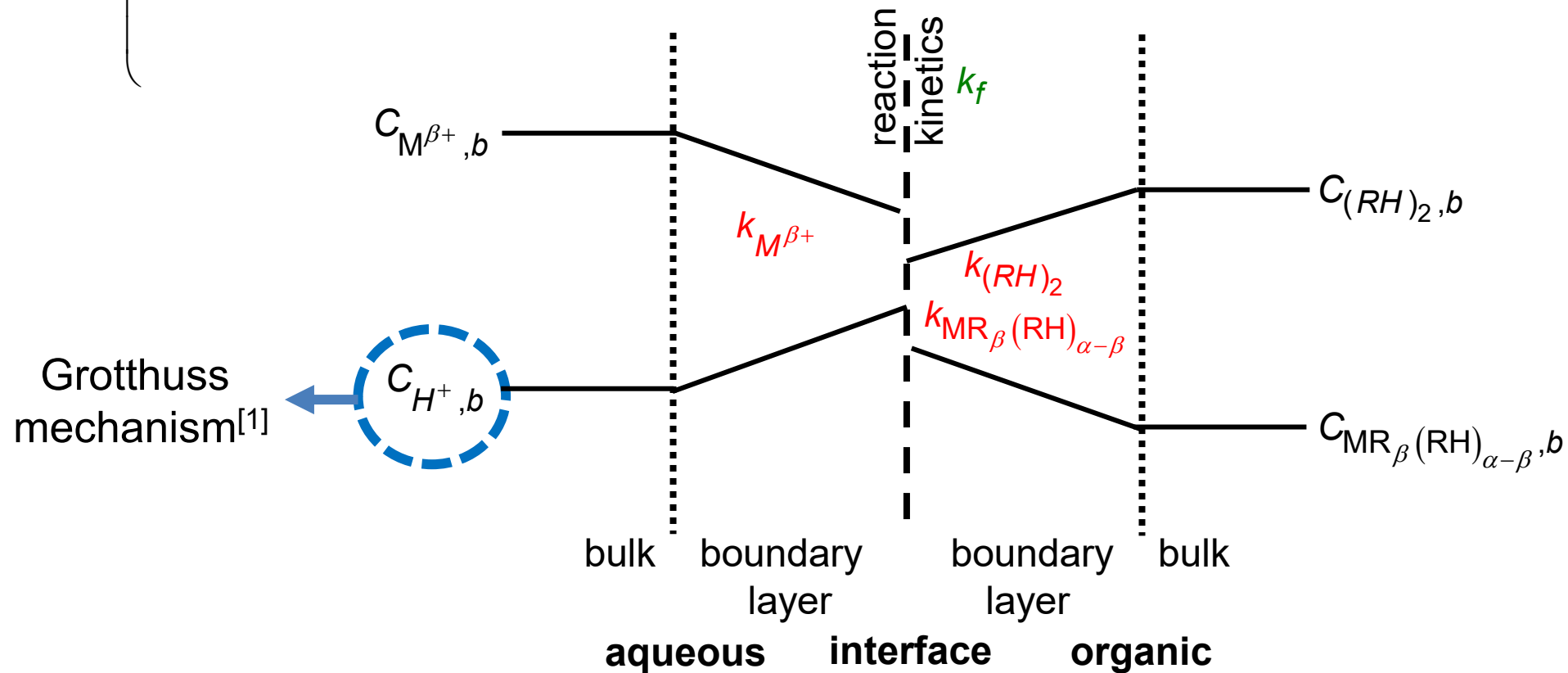
# determining individual mass-transfer coefficient

$$j_m'' = k_f \left( \left( C_{M^{\beta+},b} + \frac{v_{M^{\beta+}} \xi''}{k_{M^{\beta+}}} \right) \left( C_{(HR)_2,b} + \frac{v_{(HR)_2} \xi''}{k_{(HR)_2}} \right)^{-v_{(HR)_2}} - \frac{\left( C_{(MR_\alpha HR)_{\alpha-\beta},b} + \frac{v_{(MR_\alpha HR)_{\alpha-\beta}} \xi''}{k_{(MR_\alpha HR)_{\alpha-\beta}}} \right) \left( C_{H^+,b} + \frac{v_{H^+} \xi''}{k_{H^+}} \right)^{v_{H^+}}}{K_c} \right)$$



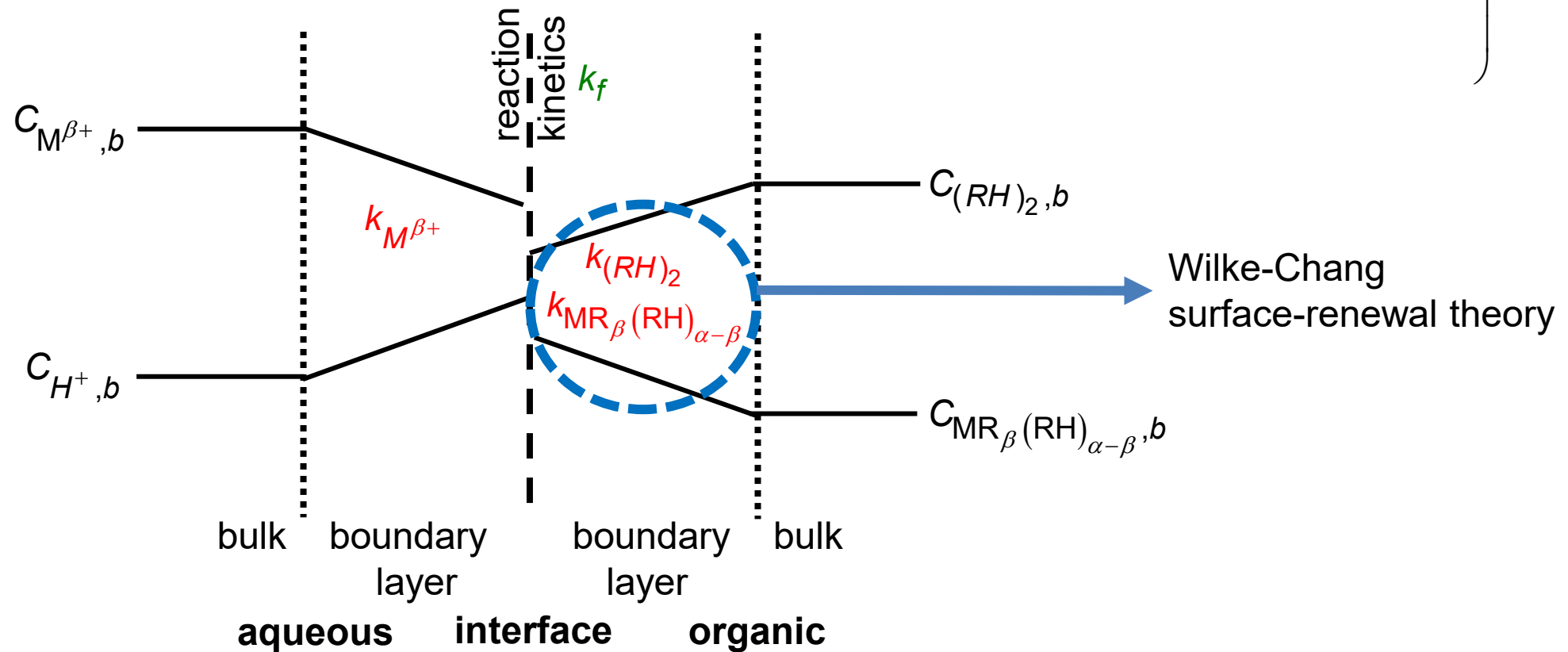
# decreasing number of free parameters

$$j_m'' = k_f \left( \left( C_{M^{\beta+},b} + \frac{v_{M^{\beta+}} \xi''}{k_{M^{\beta+}}} \right) \left( C_{(HR)_2,b} + \frac{v_{(HR)_2} \xi''}{k_{(HR)_2}} \right)^{-v_{(HR)_2}} \frac{\left( C_{(MR_\alpha HR)_{\alpha-\beta},b} + \frac{v_{(MR_\alpha HR)_{\alpha-\beta}} \xi''}{k_{(MR_\alpha HR)_{\alpha-\beta}}} \right) \left( C_{H^+,b} + \frac{v_{H^+} \xi''}{k_{H^+}} \right)^{v_{H^+}}}{K_c} \right)$$

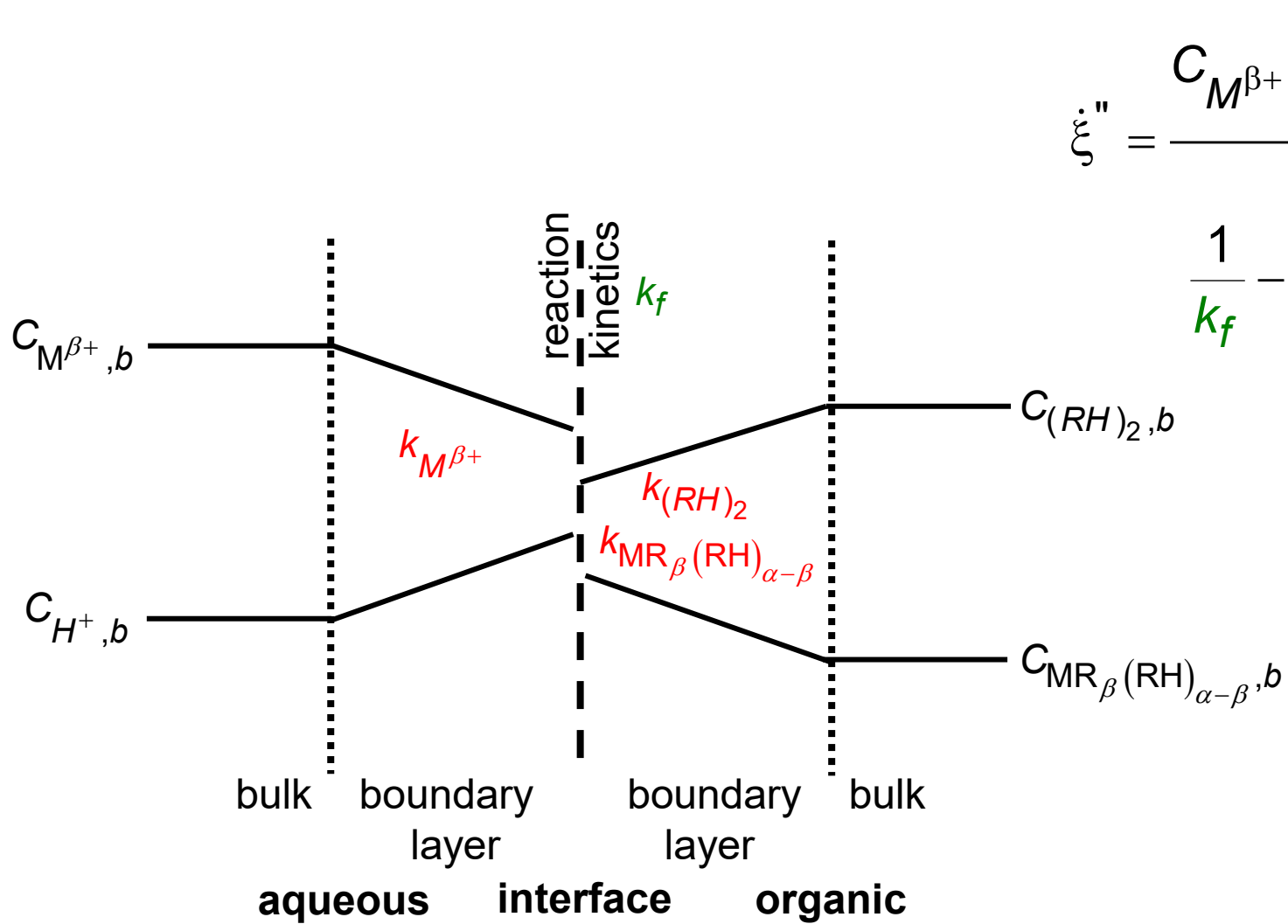


# decreasing number of free parameters

$$j_m'' = k_f \left( \left( C_{M^{\beta+},b} + \frac{v_{M^{\beta+}} \xi''}{k_{M^{\beta+}}} \right) \left( C_{(HR)_2,b} + \frac{v_{(HR)_2} \xi''}{k_{(HR)_2}} \right)^{-v_{(HR)_2}} \frac{\left( C_{(MR_\alpha HR)_{\alpha-\beta},b} + \frac{v_{(MR_\alpha HR)_{\alpha-\beta}} \xi''}{k_{(MR_\alpha HR)_{\alpha-\beta}}} \right) \left( C_{H^+,b} + \frac{v_{H^+} \xi''}{k_{H^+}} \right)^{v_{H^+}}}{K_c} \right)$$

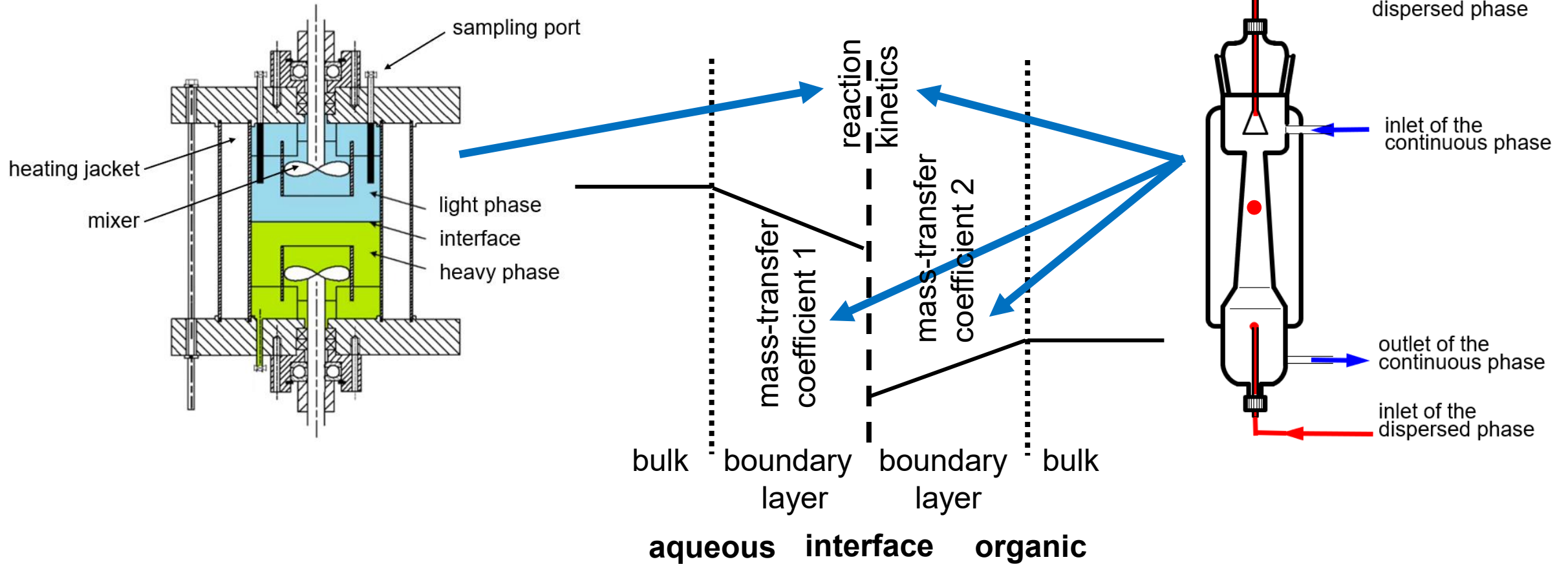
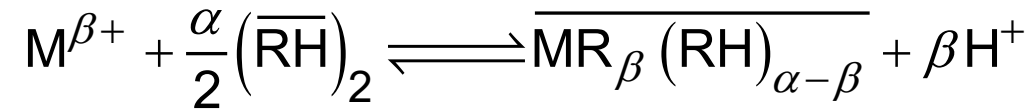


# mass transfer: excess of extractant

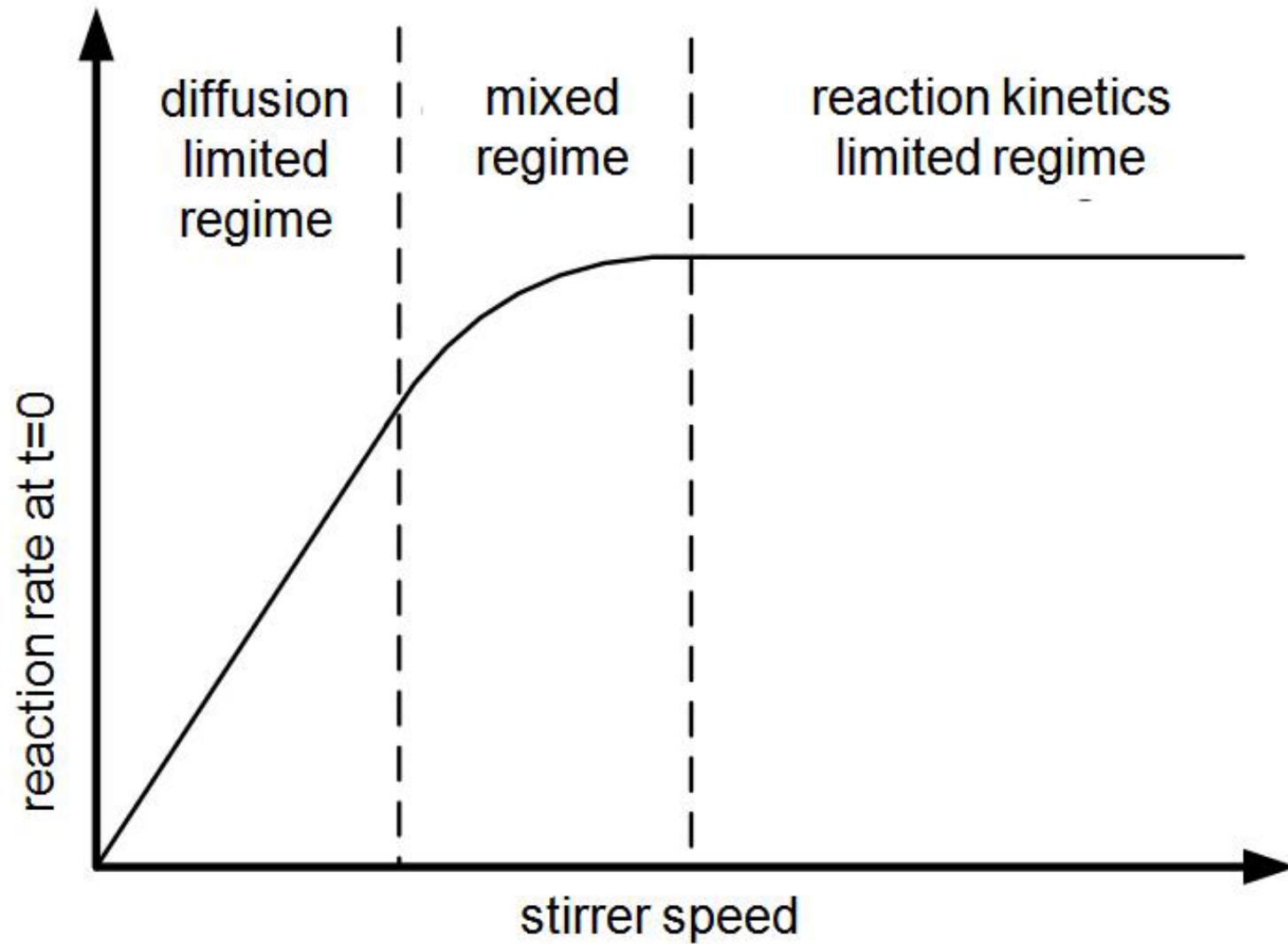


$$S_{M^{\beta+}} = \frac{C_{M^{\beta+},b} C_{(HR)_2,b}^{-\nu} - \frac{1}{K_c} C_{(MR_{\alpha}HR)_{\alpha-\beta},b} C_{H^+,b}^{\nu}}{\frac{1}{k_f} - \frac{\nu_{M^{\beta+}} C_{(HR)_2,b}^{-\nu}}{k_{M^{\beta+}}} + \frac{\nu_{(MR_{\alpha}HR)_{\alpha-\beta}} C_{H^+,b}^{\nu}}{K_c k_{(MR_{\alpha}HR)_{\alpha-\beta}}}}$$

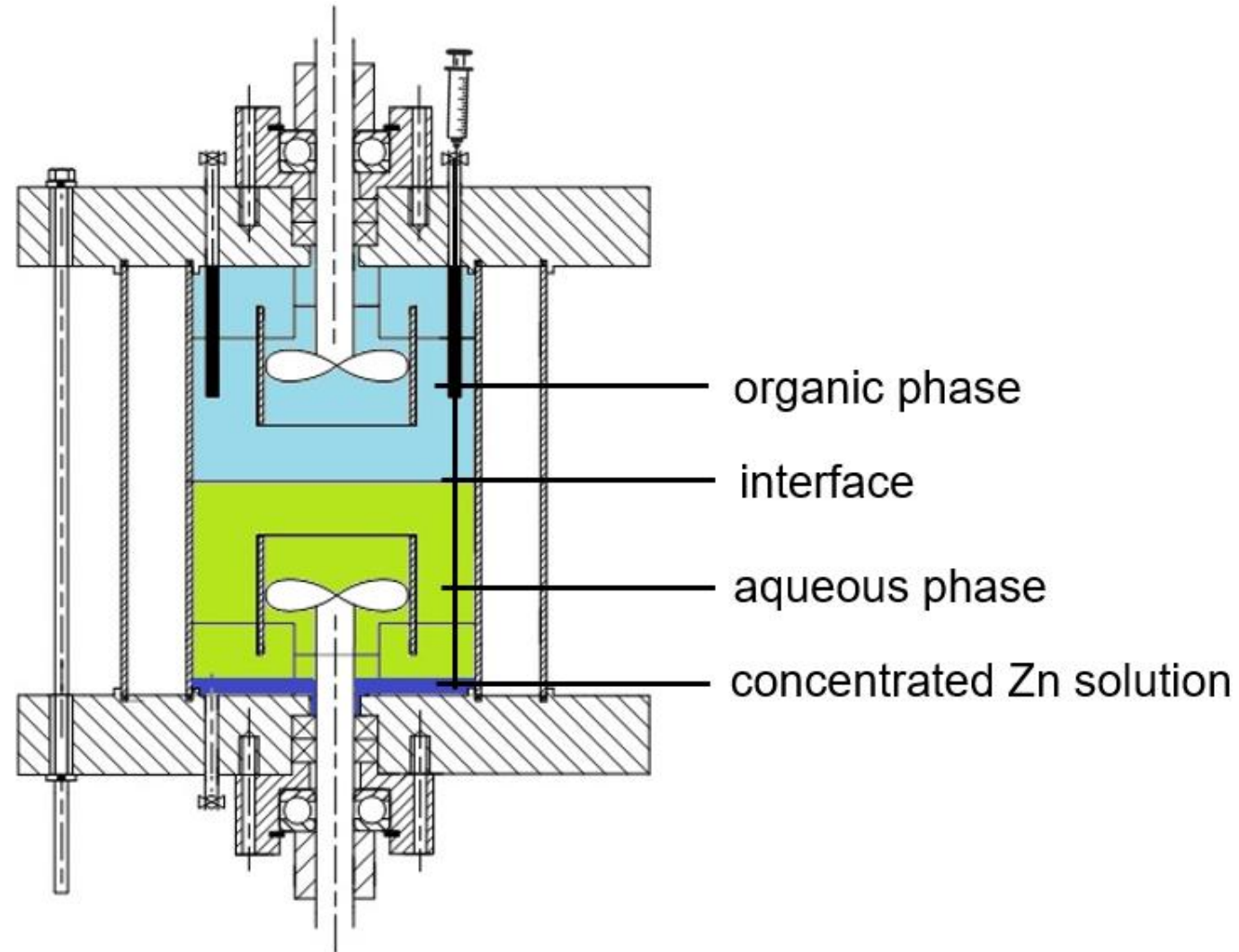
# reactive mass-transfer kinetics



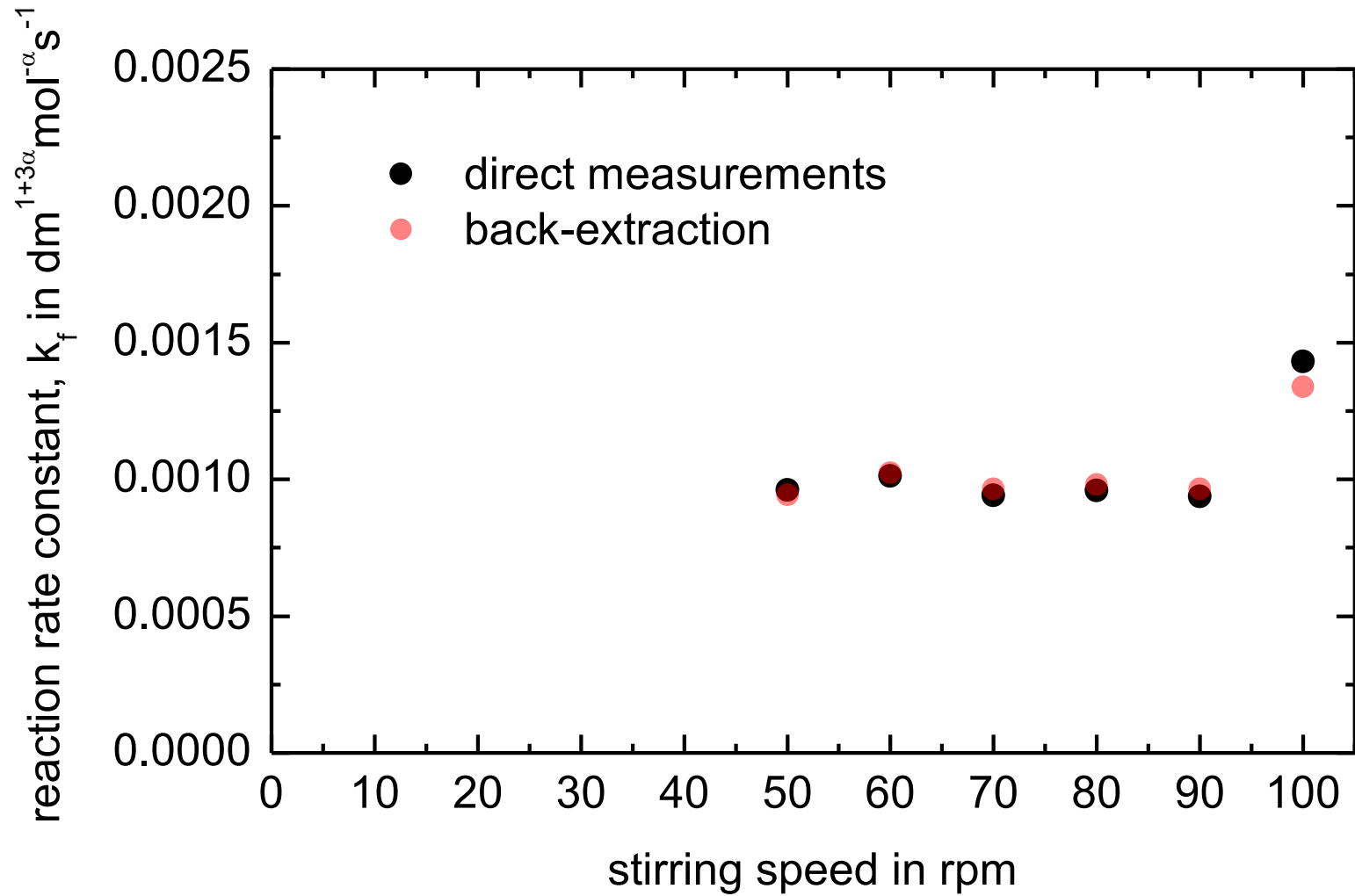
# initial mass-transfer rate as function stirrer speed



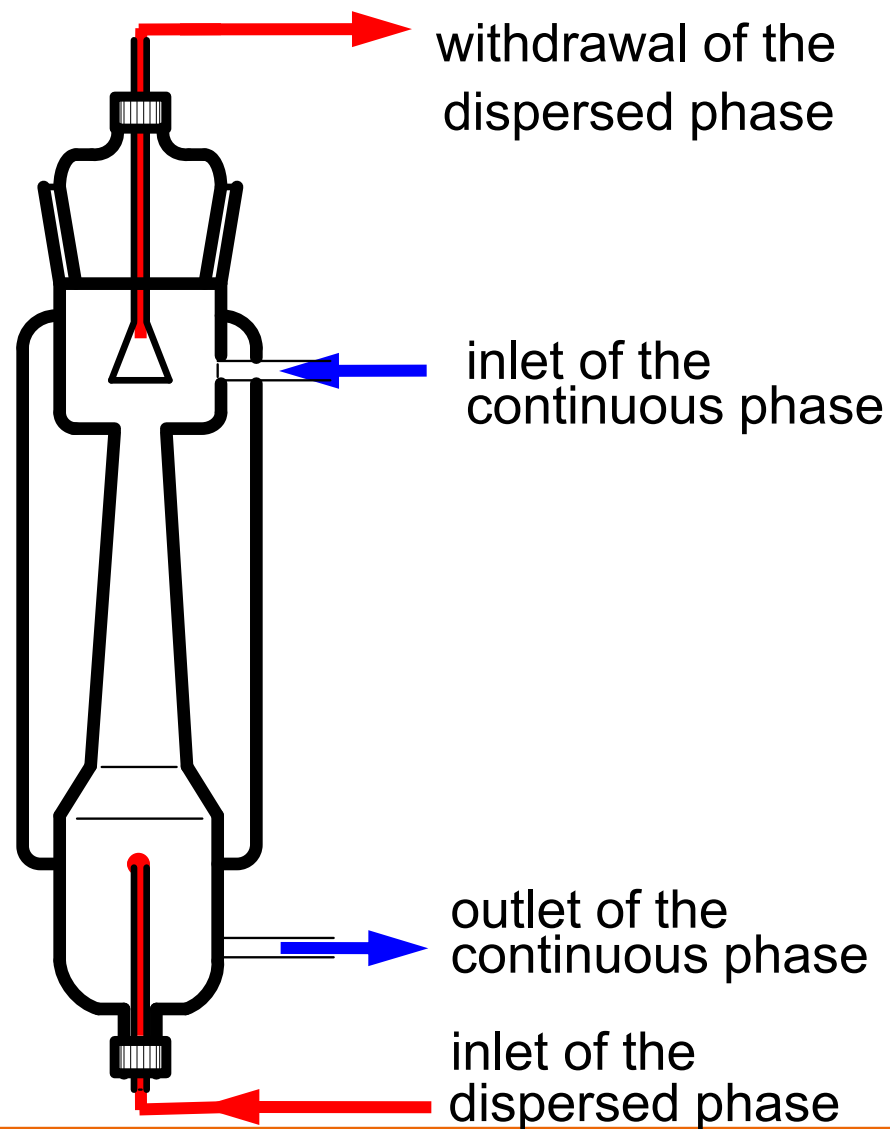
# Nitsch cell



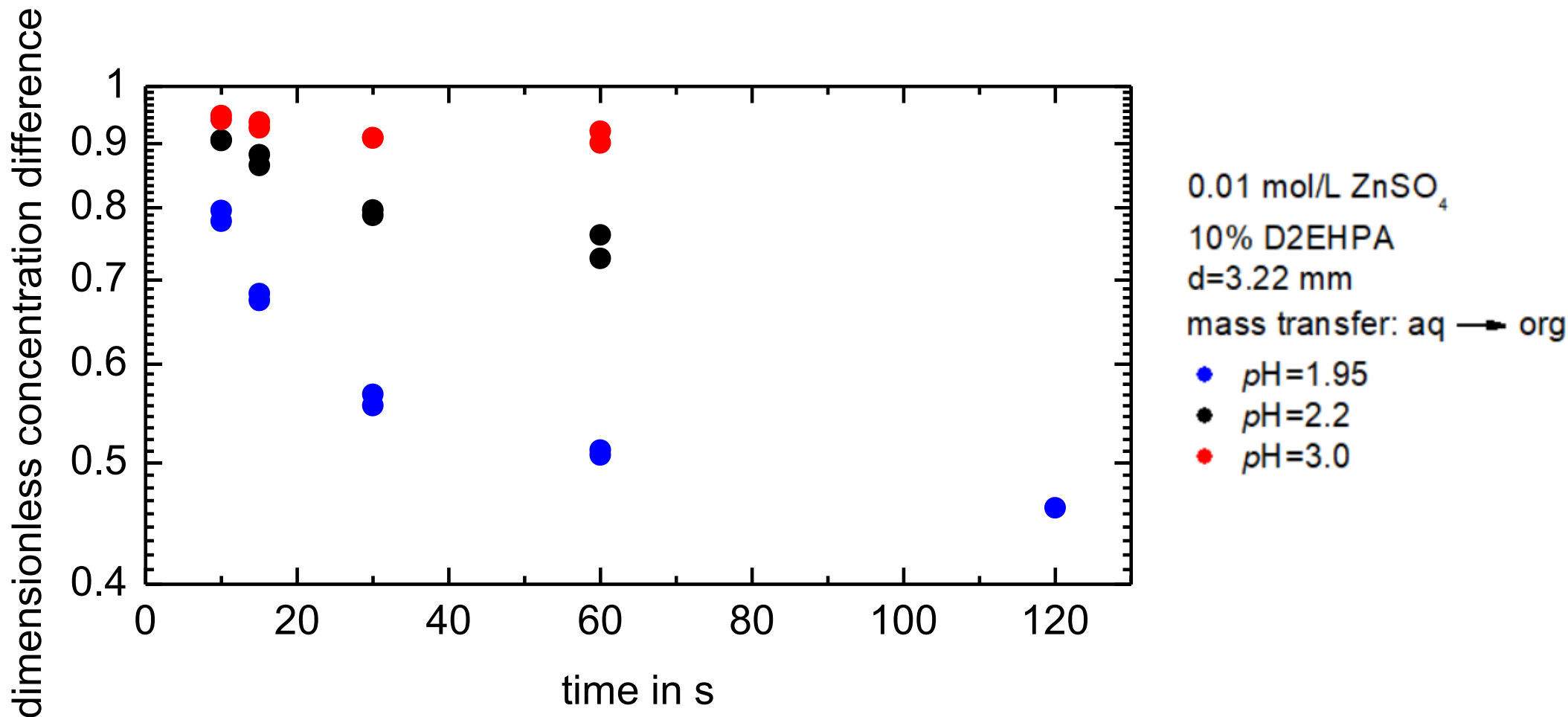
# determining rate constant



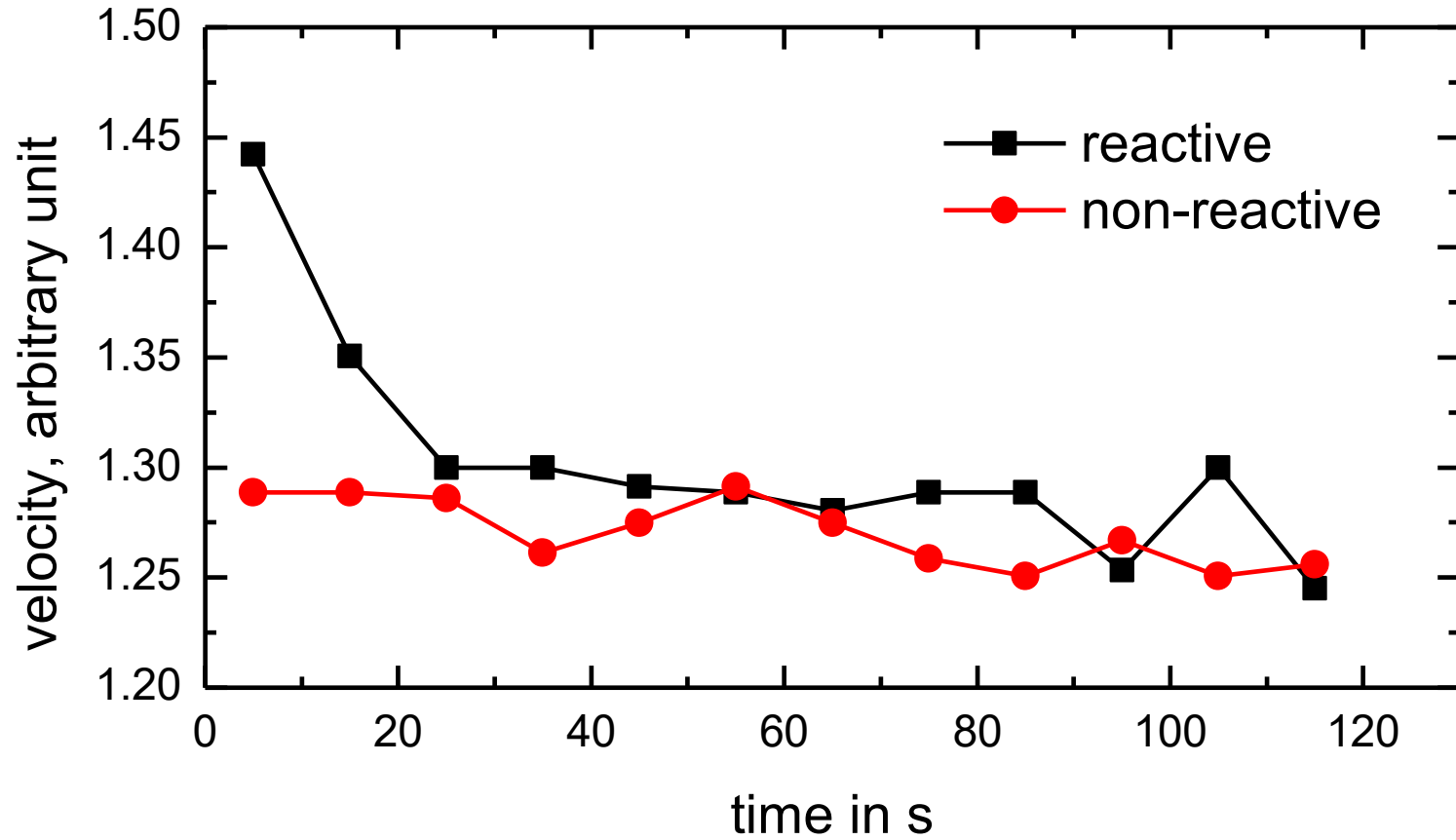
# single-drop cell



# pH effect



# drop velocity



# conclusion

- equilibrium experiments  $\longrightarrow K_{C,\alpha}$
- Wilke-Chang & surface-renewal theory  $\longrightarrow$  ratio  $k_{MR_\beta(RH)_{\alpha-\beta}} / k_{(RH)_2}$
- Nitsch cell  $\longrightarrow$  interfacial forward reaction-rate constant  $k_f$
- single-drop cell  $\longrightarrow$  mass-transfer coefficients  $k_{M^{\beta+}}$  and  $k_{MR_\beta(RH)_{\alpha-\beta}}$
- next step: single-drop experiments with varying extractant concentration

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