

Thermodynamic Efficiency in Dissipative Chemistry Coffee

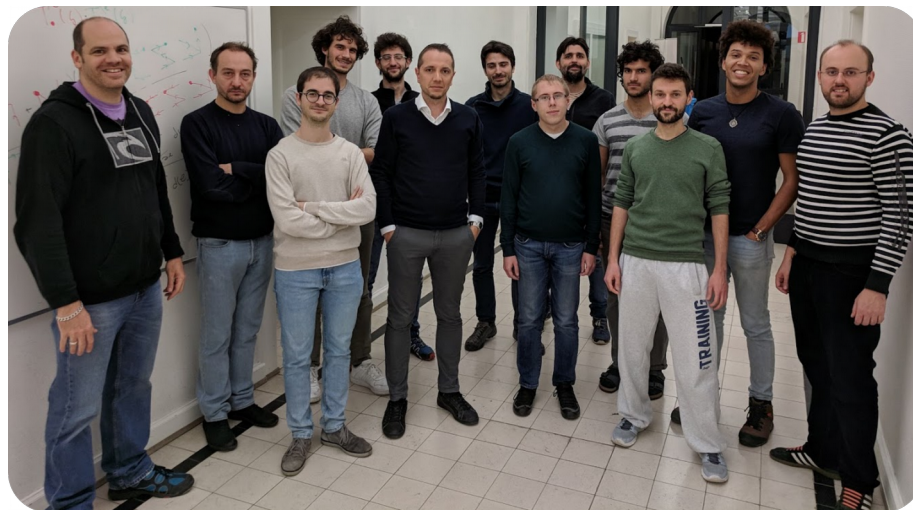
Emanuele Penocchio, Riccardo Rao, Massimiliano Esposito



UNIVERSITÉ DU
LUXEMBOURG



European
Research
Council

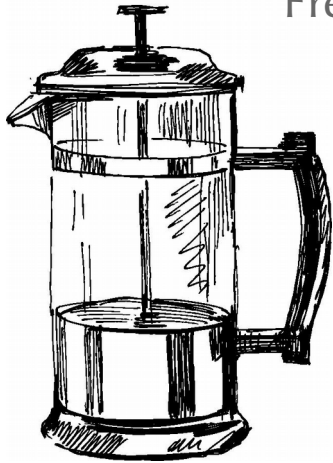


Fonds National de la
Recherche Luxembourg

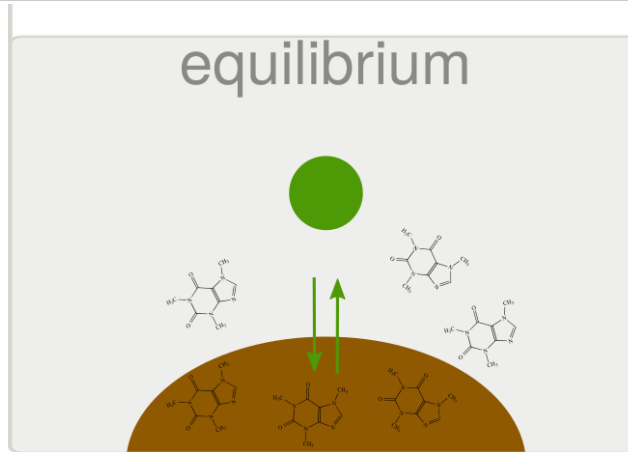
Kraków, 19 Sept. 2019 - emanuele.penocchio@uni.lu

our work in a coffee bean

French press

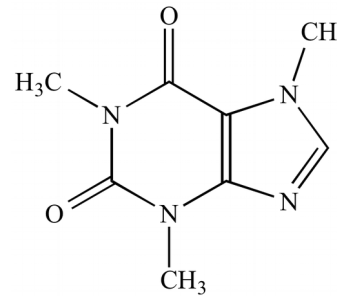


equilibrium

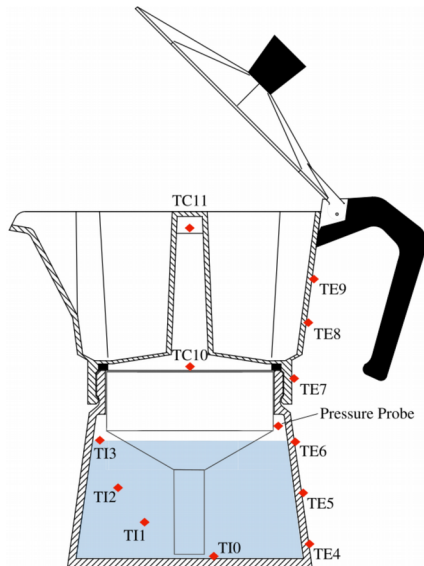


$$\eta \sim \frac{\text{output}}{\text{input}} (?)$$

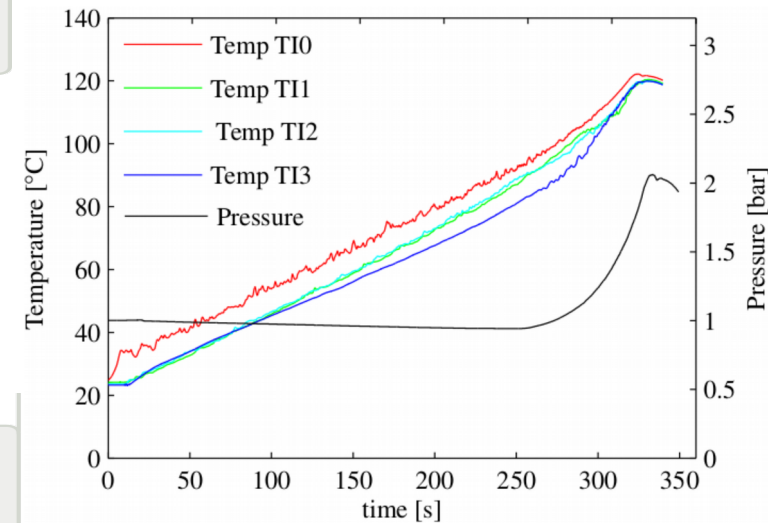
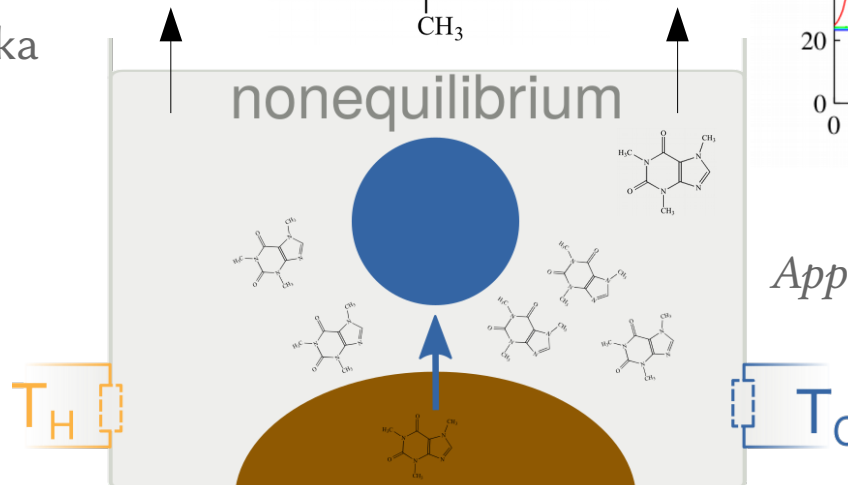
caffeine:



Moka



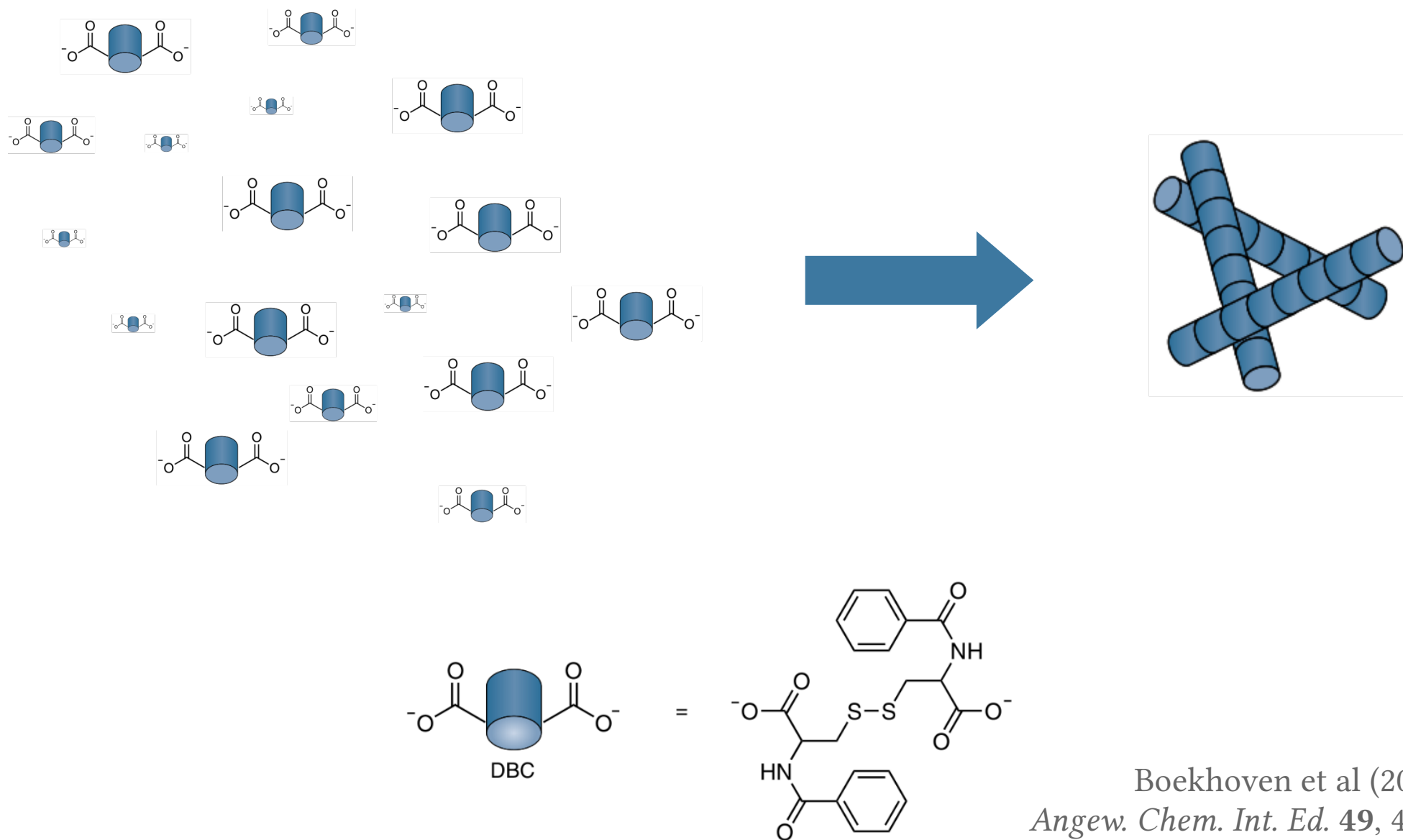
nonequilibrium



Navarini et al (2009)
Applied Thermal Engineering **29**, 998

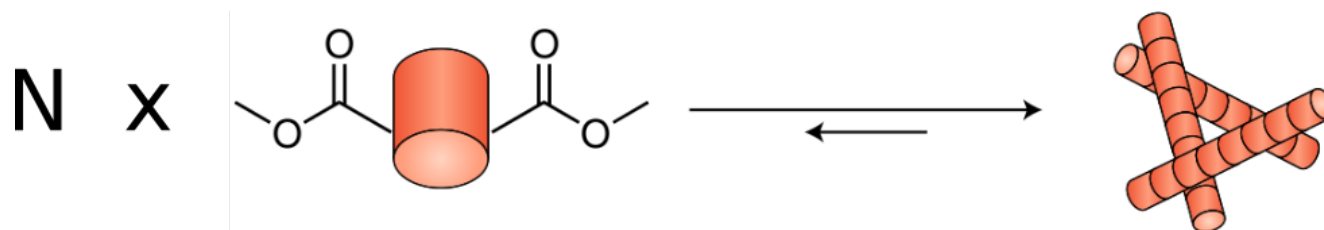
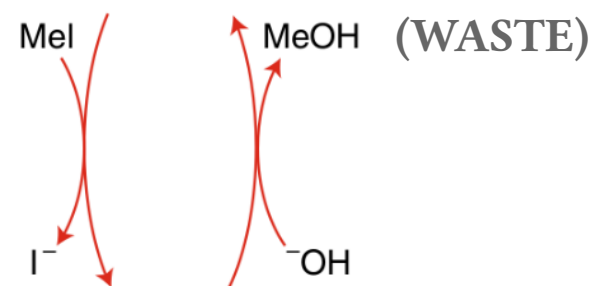
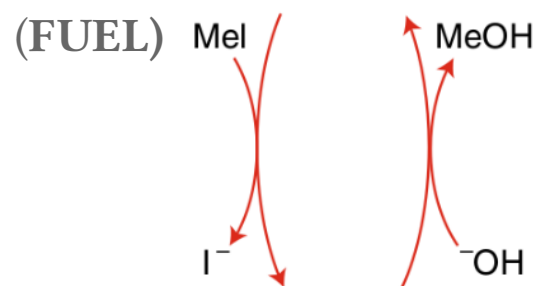
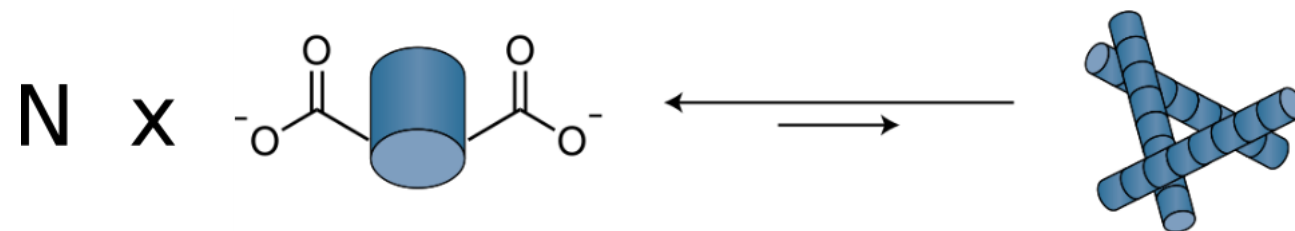
More possibilities out of equilibrium!

Dissipative Self-Assembly as case study



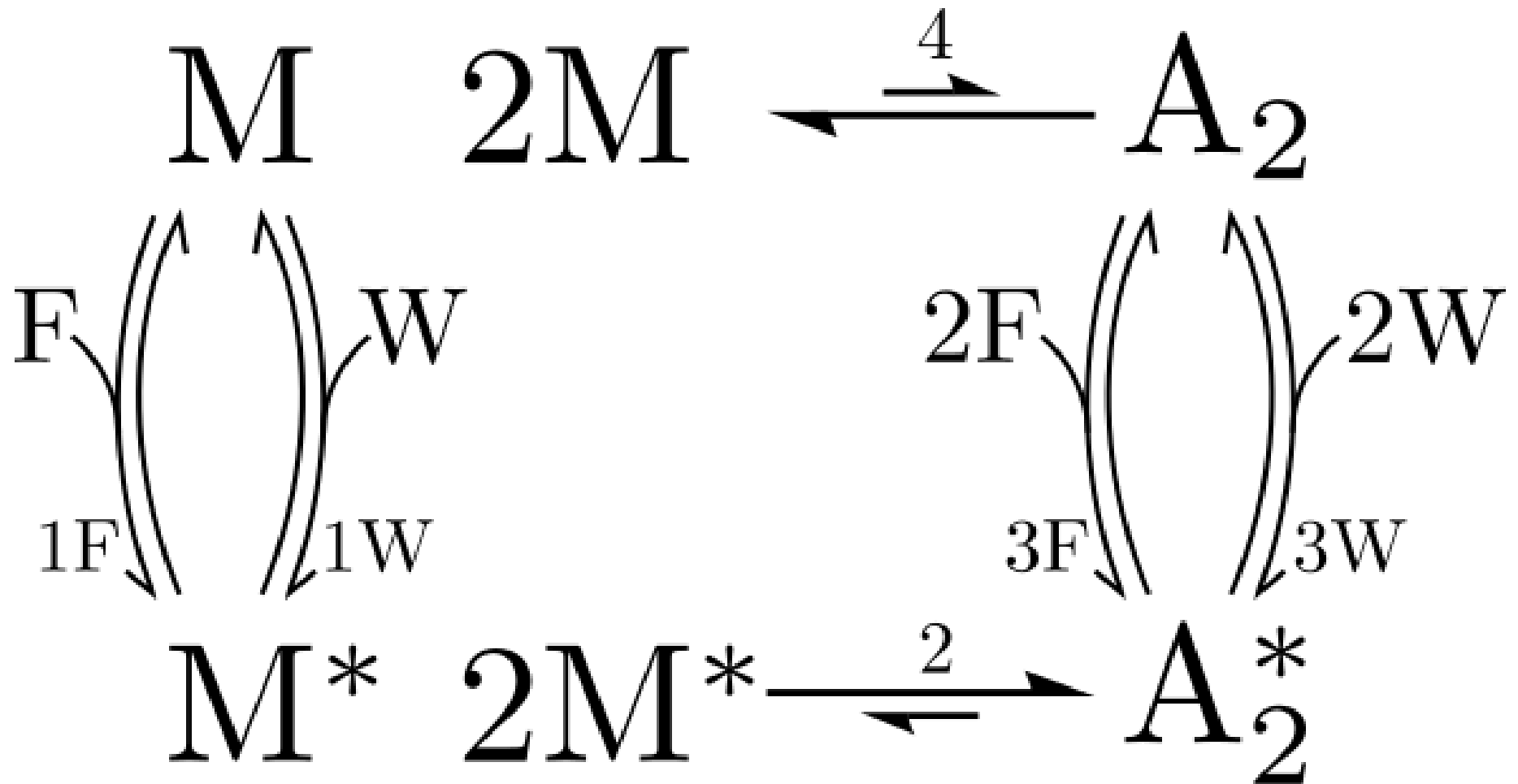
Boekhoven et al (2010)
Angew. Chem. Int. Ed. **49**, 4825

Dissipative Self-Assembly as case study



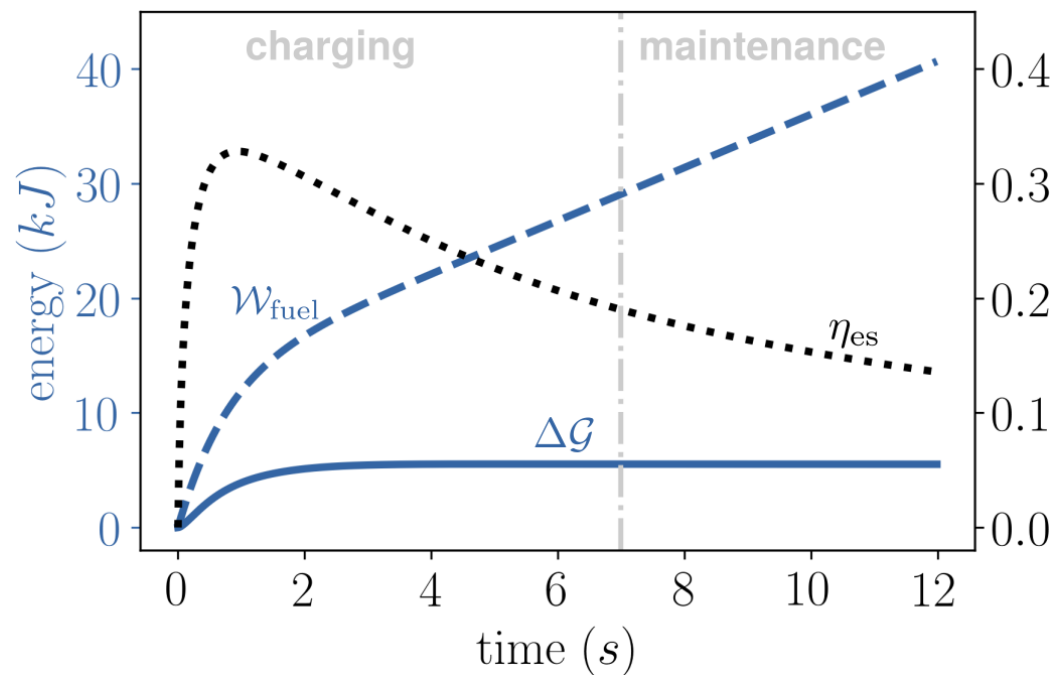
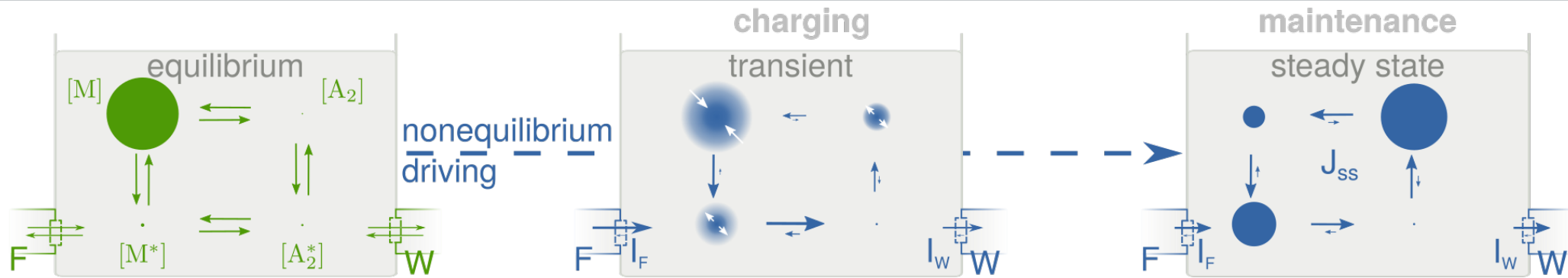
Ragazzon G. & Prins L. (2018)
Nature Nanotech. **13**, 882

Dissipative Self-Assembly as case study



Theory valid for ideal dilute solutions in mass action regime

Energy Storage



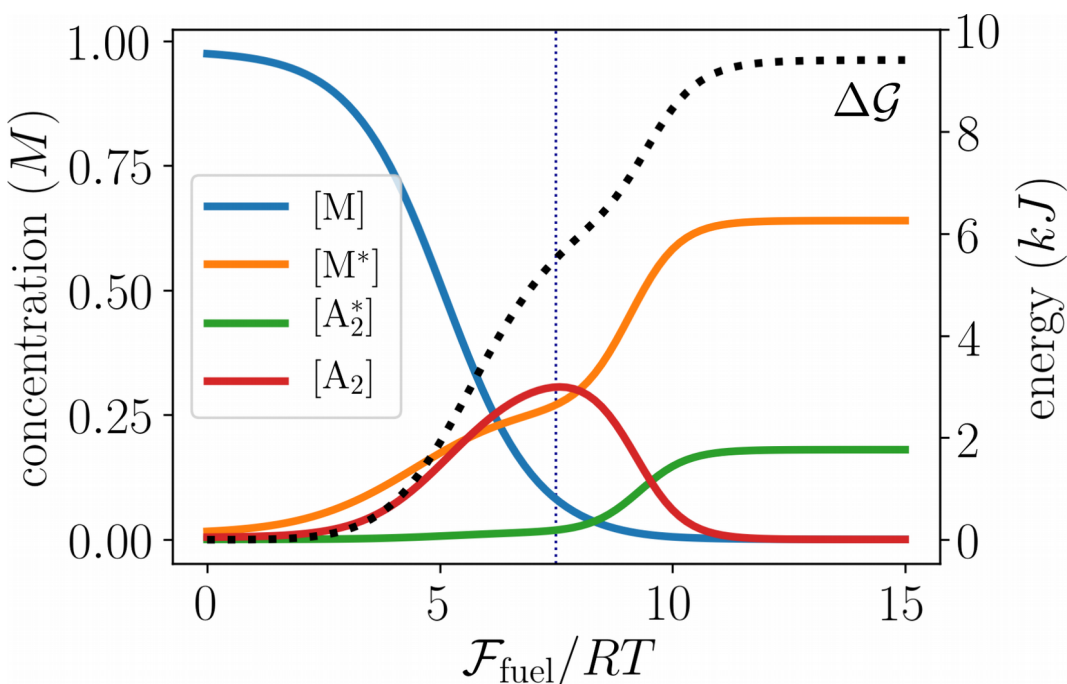
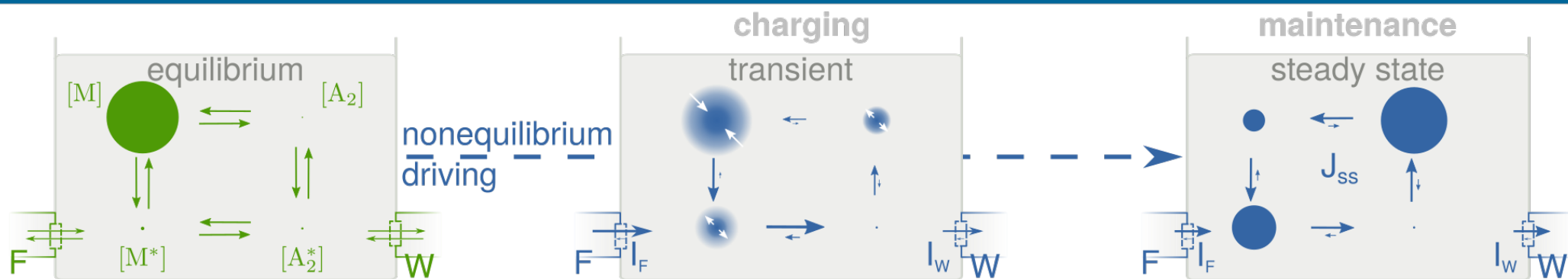
$$\dot{\mathcal{W}}_{\text{fuel}} := I_F \cdot (\mu_F - \mu_W) = I_F \cdot \mathcal{F}_{\text{fuel}}$$

$$\Delta \mathcal{G} = RT \sum_X \left[[X] \ln \frac{[X]}{[X]_{\text{eq}}} - [X] + [X]_{\text{eq}} \right] \geq 0$$

$$\mathcal{W}_{\text{fuel}} = T\Sigma + \Delta \mathcal{G}$$

$$\eta_{\text{es}} = \frac{\Delta \mathcal{G}}{\mathcal{W}_{\text{fuel}}} = 1 - \frac{T\Sigma}{\mathcal{W}_{\text{fuel}}}$$

an example of Negative Differential Response



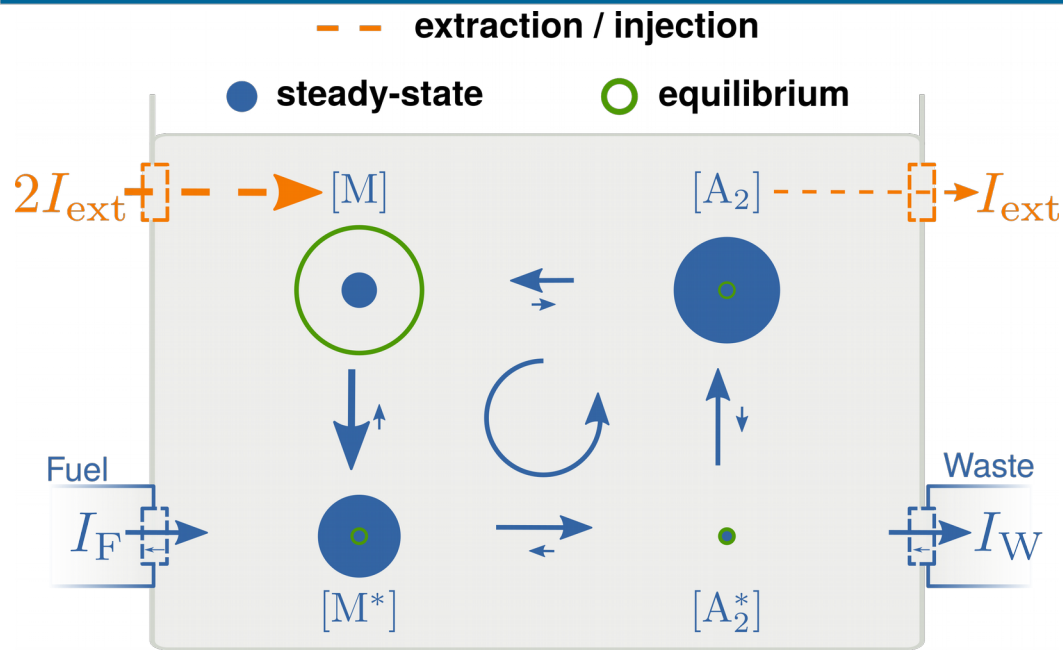
$$\dot{\mathcal{W}}_{\text{fuel}} := I_F \cdot (\mu_F - \mu_W) = I_F \cdot \mathcal{F}_{\text{fuel}}$$

$$\Delta\mathcal{G} = RT \sum_X \left[[X] \ln \frac{[X]}{[X]_{\text{eq}}} - [X] + [X]_{\text{eq}} \right] \geq 0$$

$$\mathcal{W}_{\text{fuel}} = T\Sigma + \Delta\mathcal{G}$$

$$\eta_{\text{es}} = \frac{\Delta\mathcal{G}}{\mathcal{W}_{\text{fuel}}} = 1 - \frac{T\Sigma}{\mathcal{W}_{\text{fuel}}}$$

Driven Synthesis

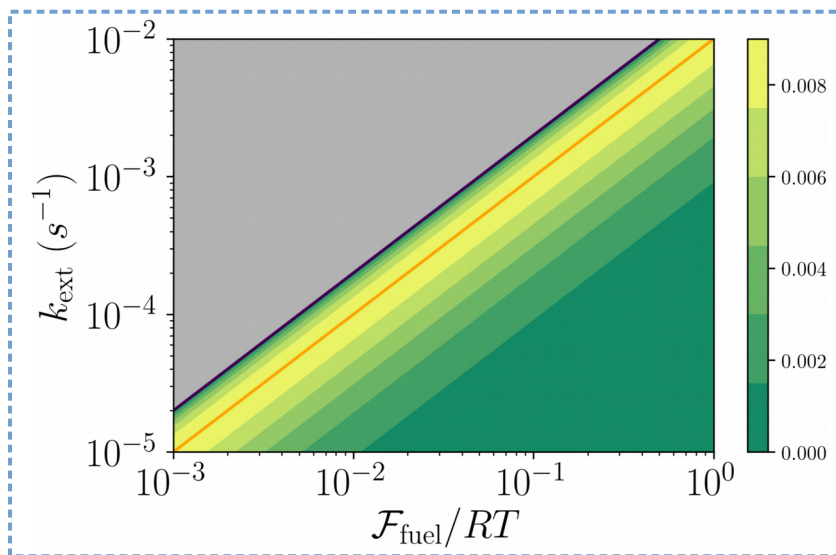


$$I_{\text{ext}} = k_{\text{ext}} \cdot [A_2]$$

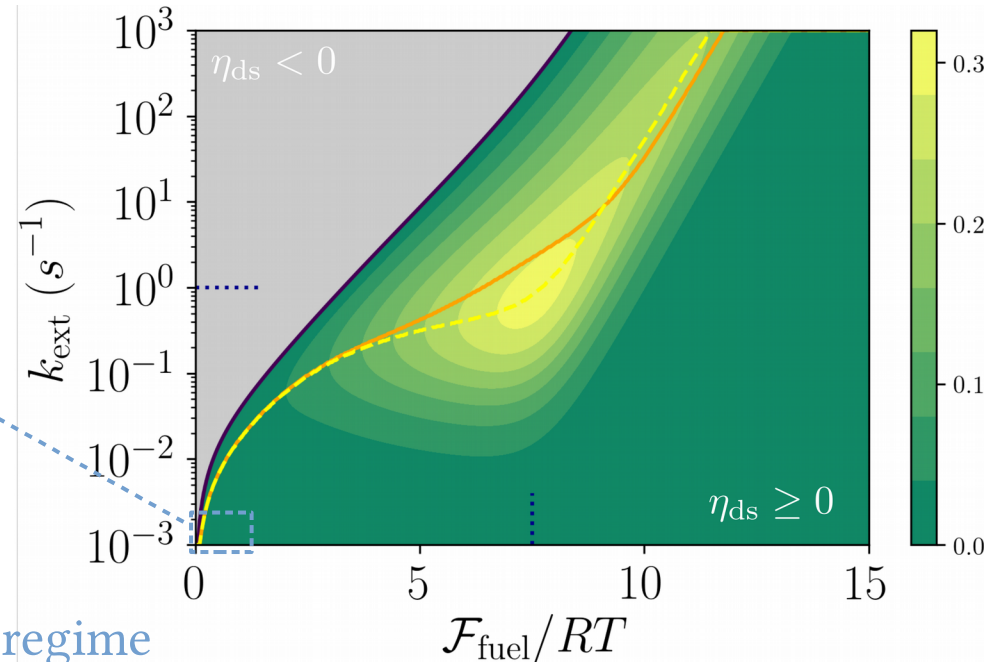
$$\dot{W}_{\text{ext}} := I_{\text{ext}} \cdot (2\mu_{\text{M}} - \mu_{\text{A}_2})$$

$$\dot{W}_{\text{fuel}} = -\dot{W}_{\text{ext}} + T\dot{\Sigma}$$

$$\eta_{\text{ds}} = -\frac{\dot{W}_{\text{ext}}}{\dot{W}_{\text{fuel}}} = 1 - \frac{T\dot{\Sigma}}{\dot{W}_{\text{fuel}}}$$



linear regime



Chemical is the new Thermal?

