A New Process Structure for Simultaneous Separation of Multiple Components at High Purity

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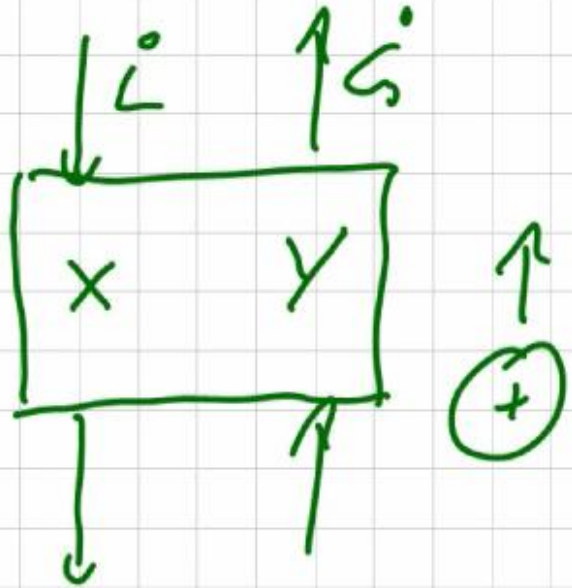
average flowrate of component considered



$$K = \frac{y}{x} \qquad \frac{\dot{G}\,y}{\dot{L}\,x} = \frac{\dot{G}}{\dot{L}}\,K = \lambda$$

$$\dot{u} = \dot{G}\,y - \dot{L}\,x$$

$$\dot{u} = \dot{L}\,x\left(\frac{\dot{G}\,y}{\dot{L}\,x} - 1\right)$$

$$\dot{u} = \dot{L}\,x\,(\lambda - 1)$$

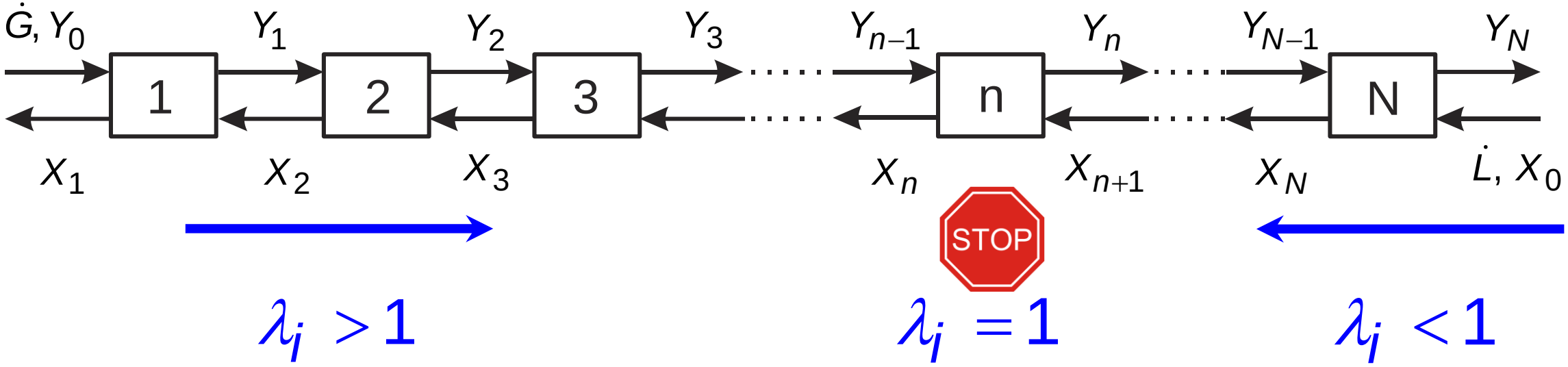
$\dot{u}\uparrow$ $\qquad$ $\dot{u}\downarrow$

$\lambda - 1 > 0$ $\qquad$ $\lambda - 1 < 0$

$\lambda > 1$ $\qquad$ $\lambda < 1$

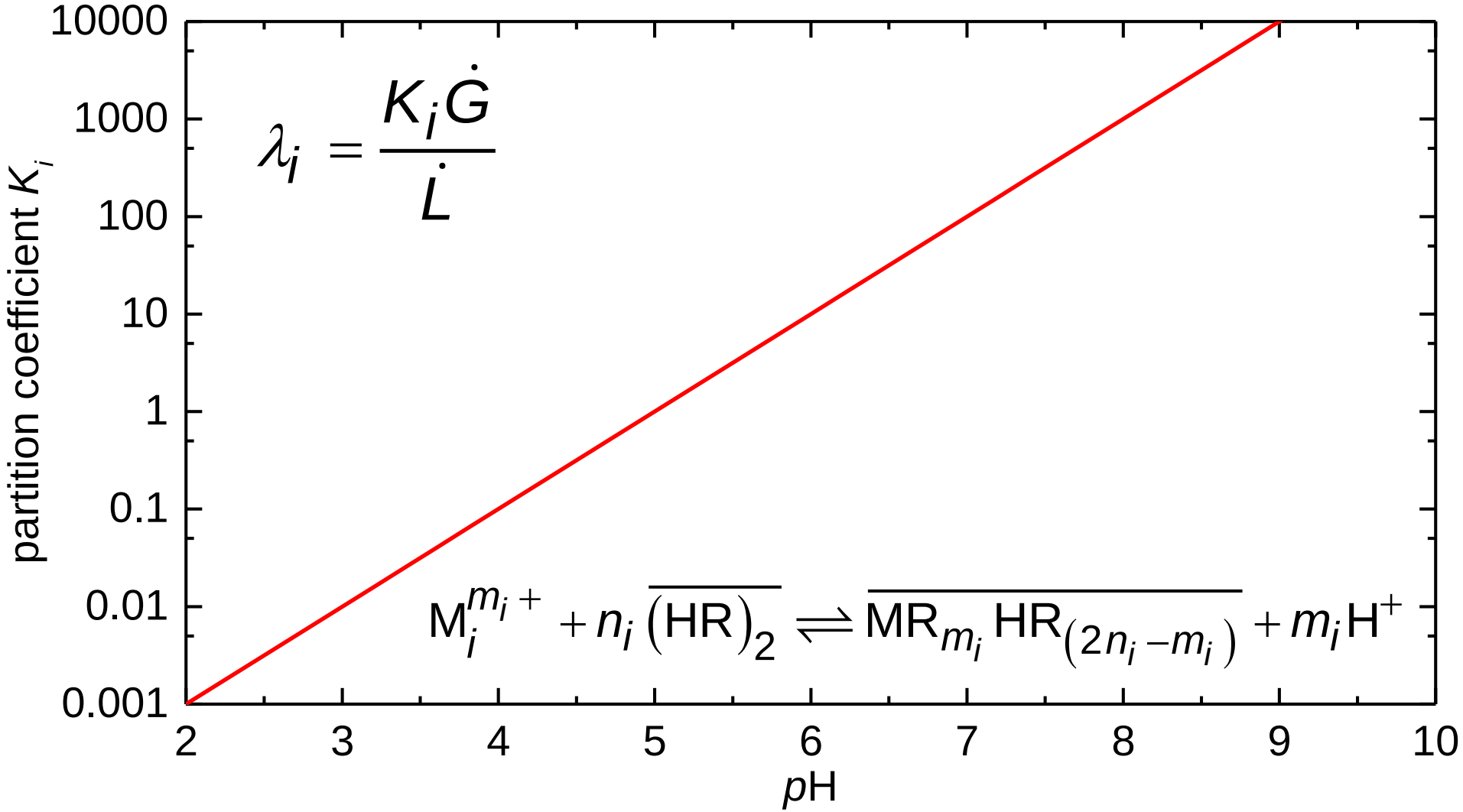
$\lambda = 1$?

counter-current process

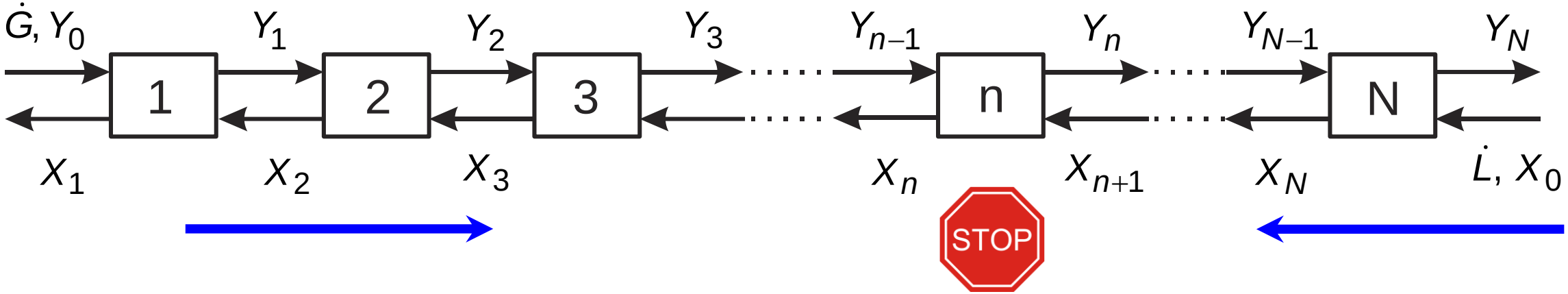


$$\lambda_i = K_i \frac{\dot{G}}{\dot{L}}$$

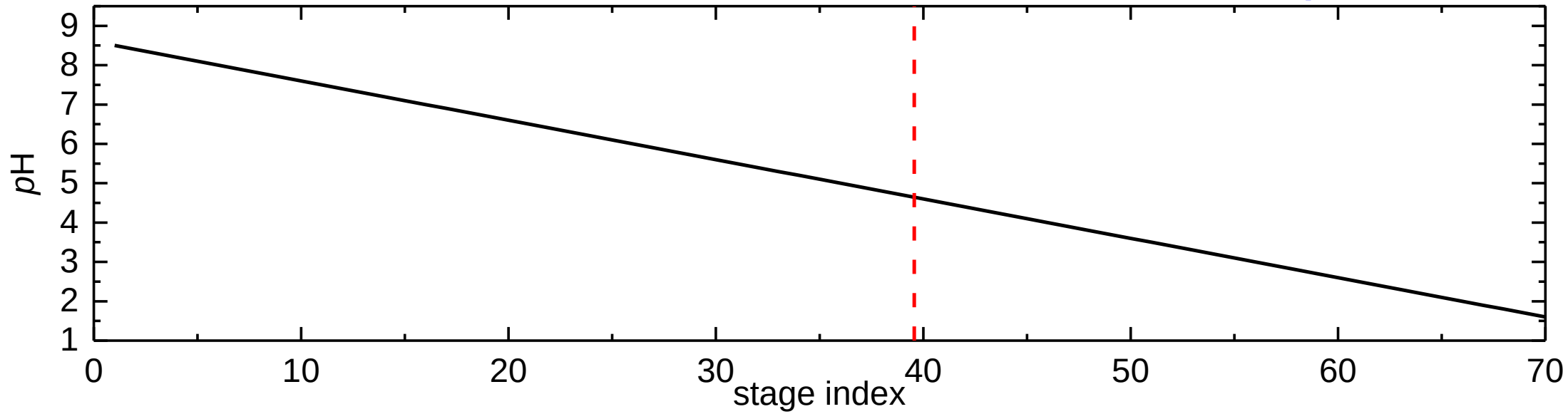
partition coefficient vs. *p*H in reactive extraction



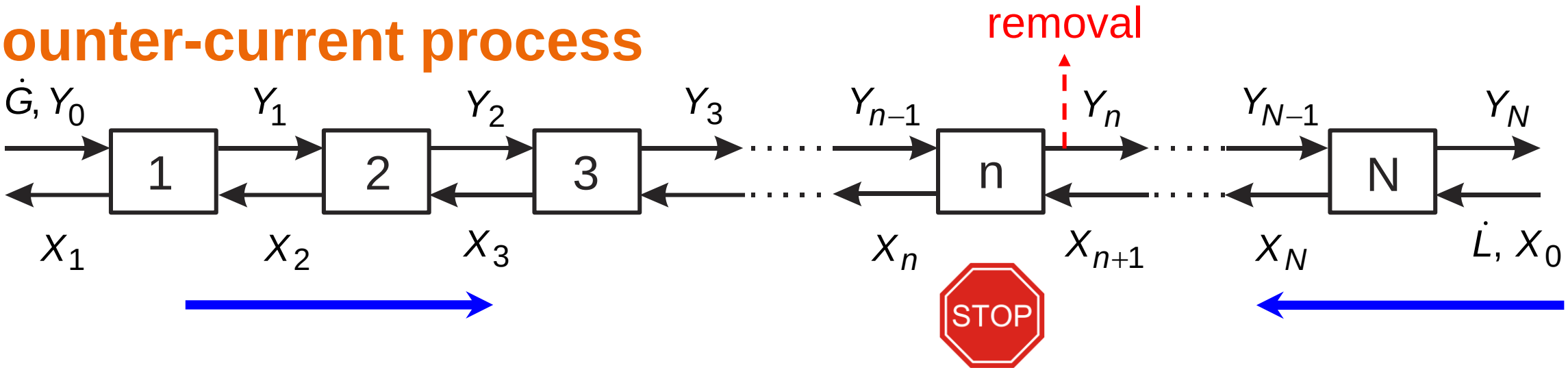
counter-current process

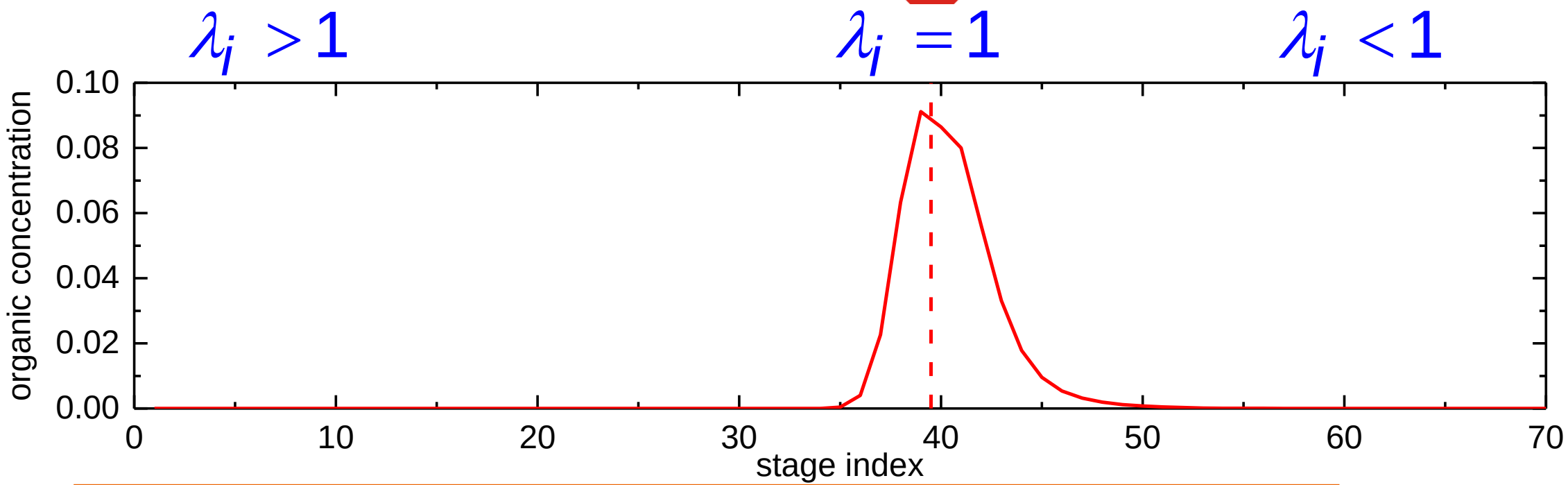


$\lambda_i > 1$ $\lambda_i = 1$ $\lambda_i < 1$

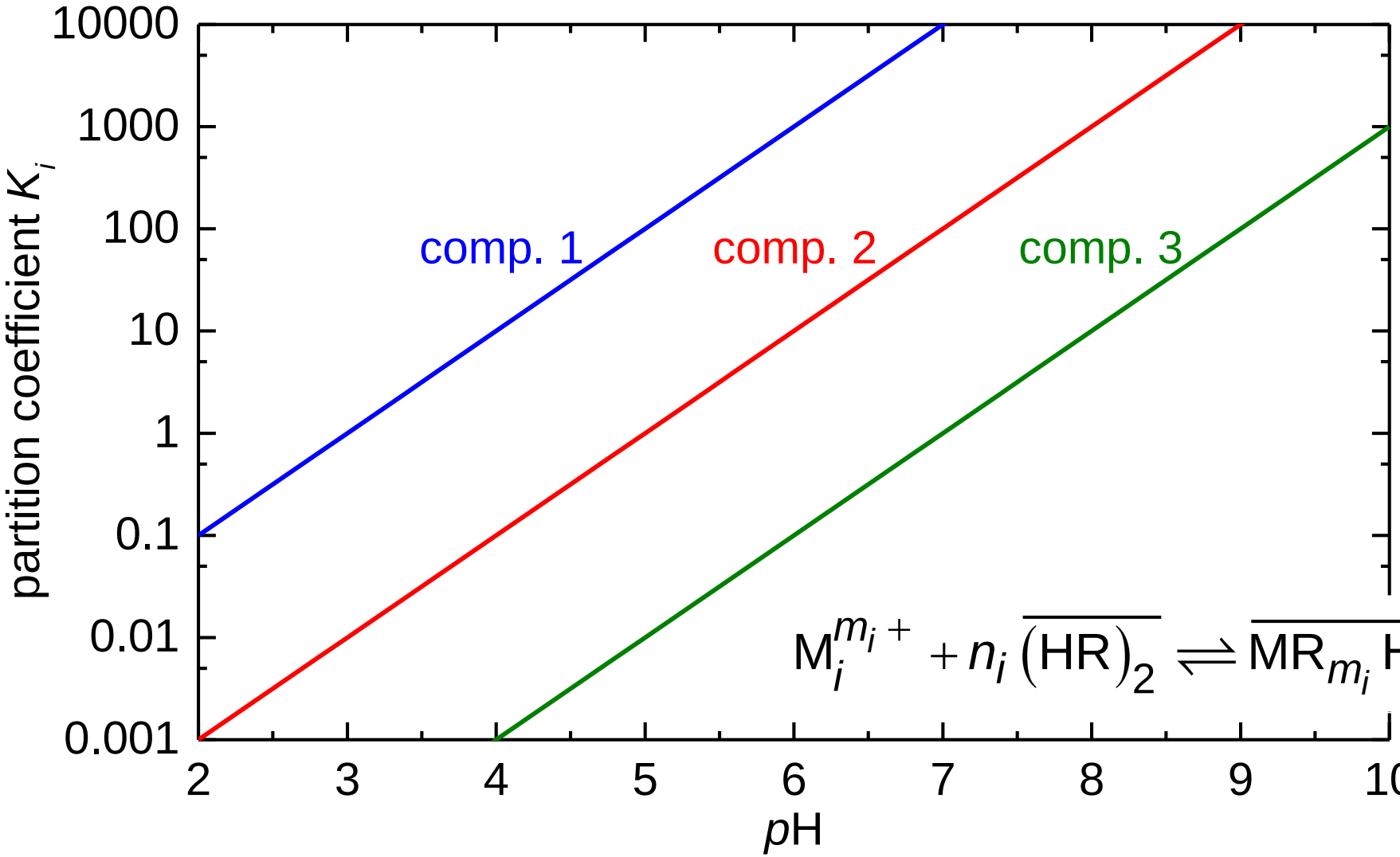


counter-current process





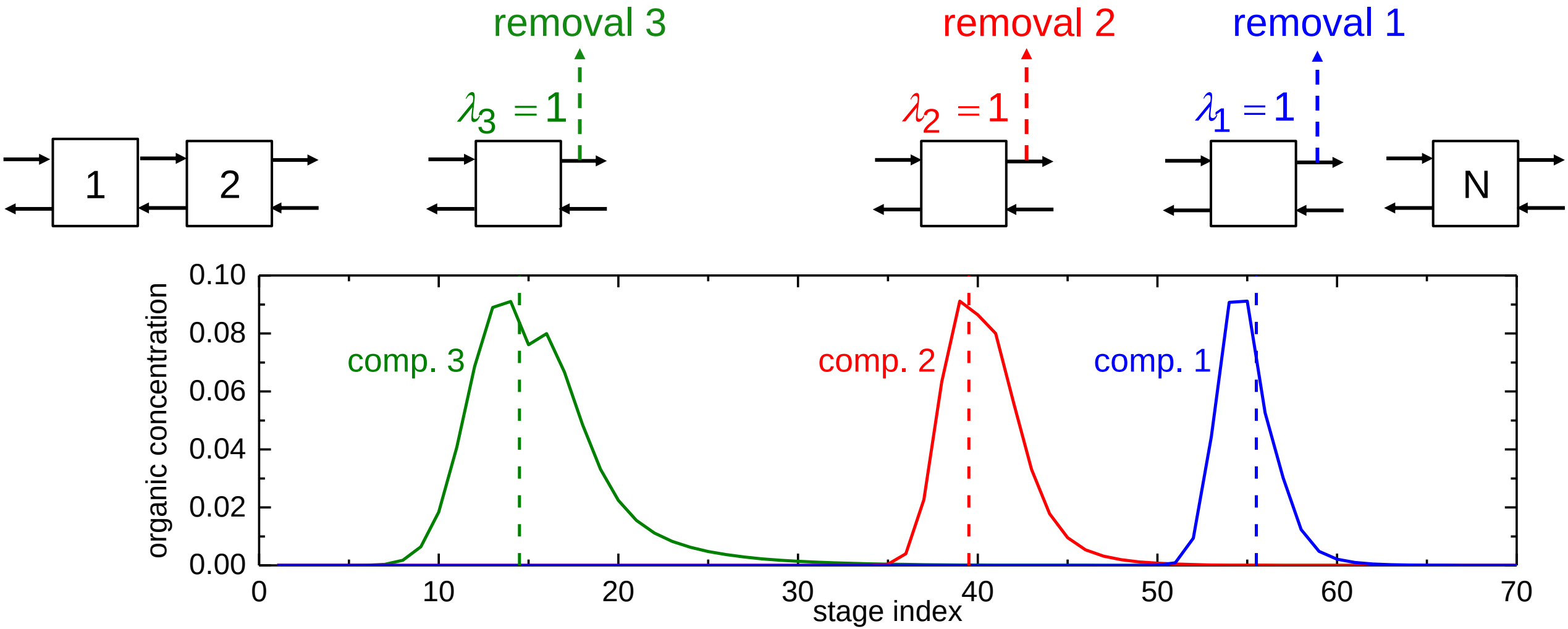
partition coefficient vs. *p*H in reactive extraction



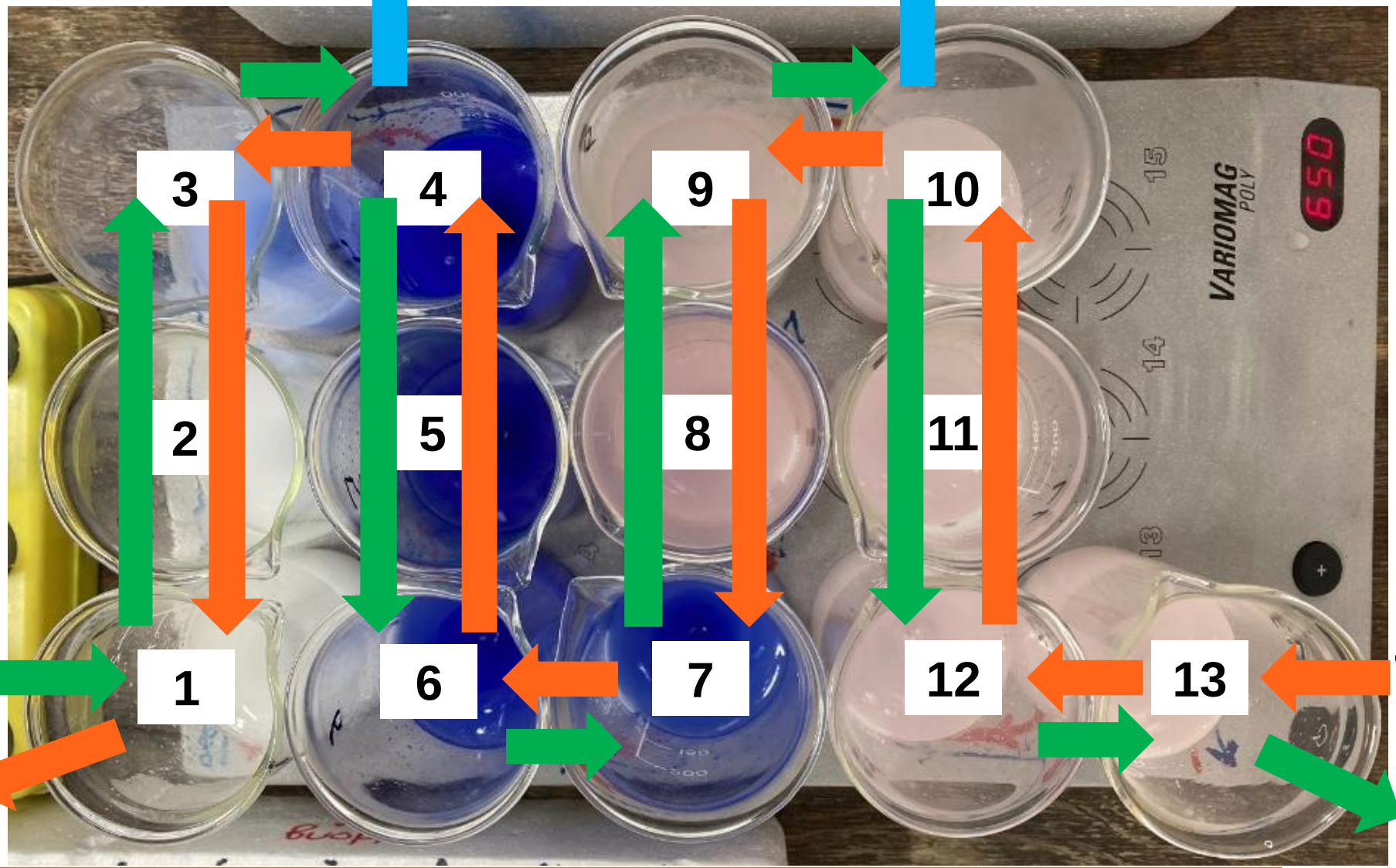
$$\lambda_i = \frac{K_i \dot{G}}{\dot{L}}$$

$$M_i^{m_i+} + n_i \overline{(HR)_2} \rightleftharpoons \overline{MR_{m_i} HR_{(2n_i - m_i)}} + m_i H^+$$

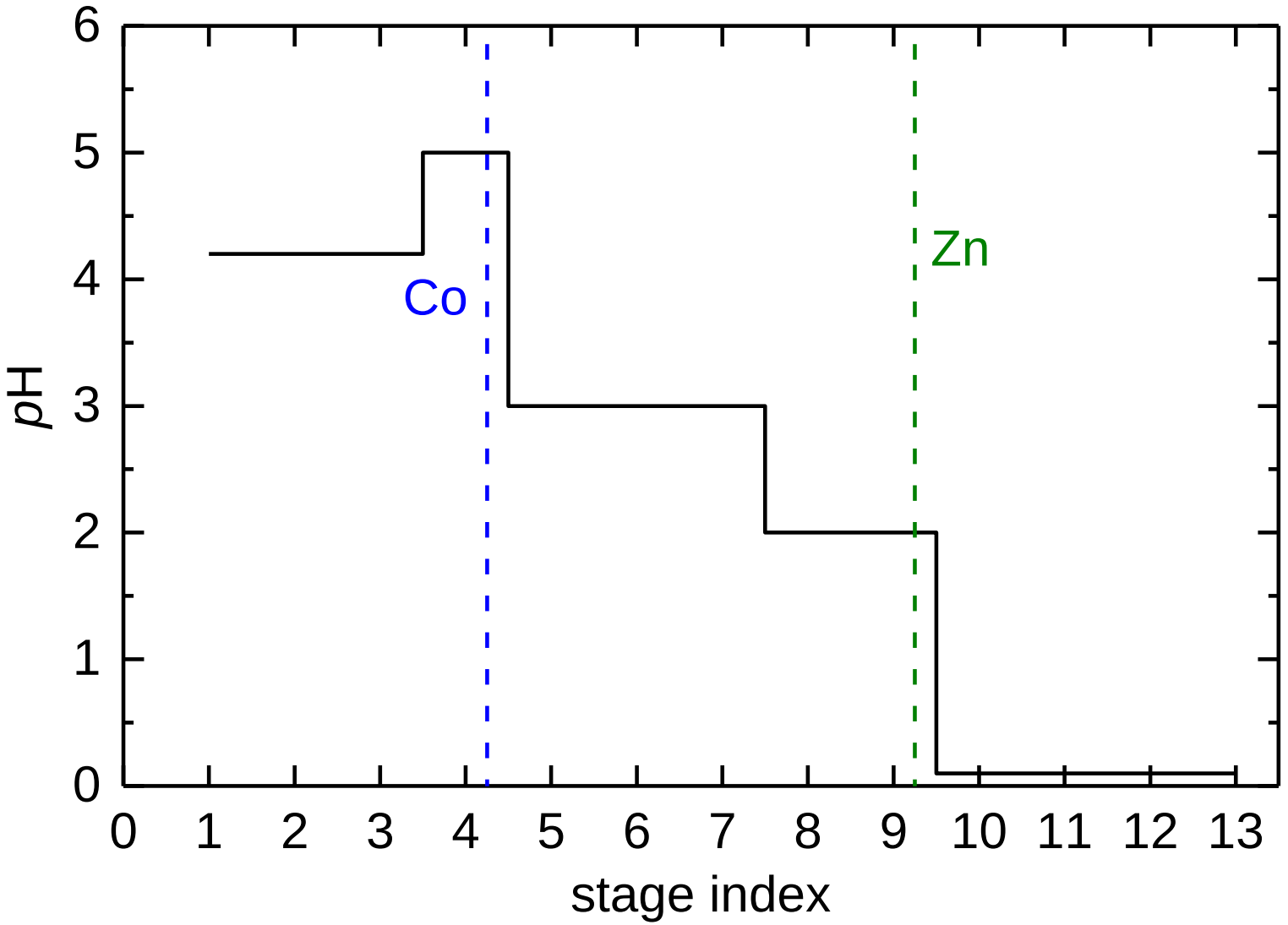
counter-current process



experimental set-up

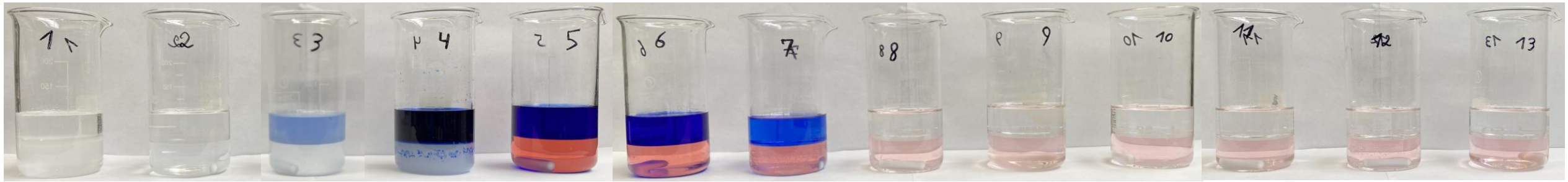


optimal *p*H-profile

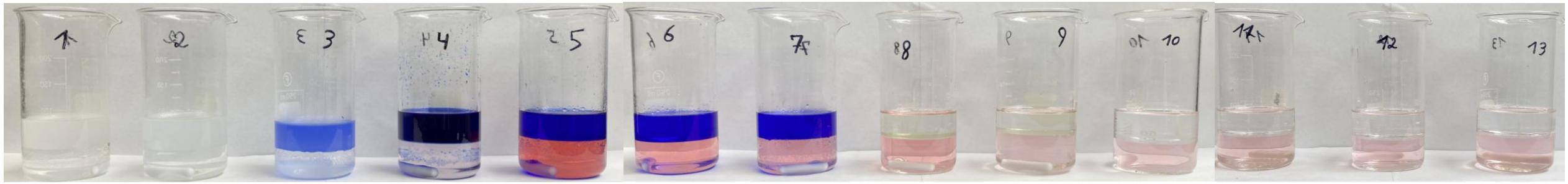


experimental results

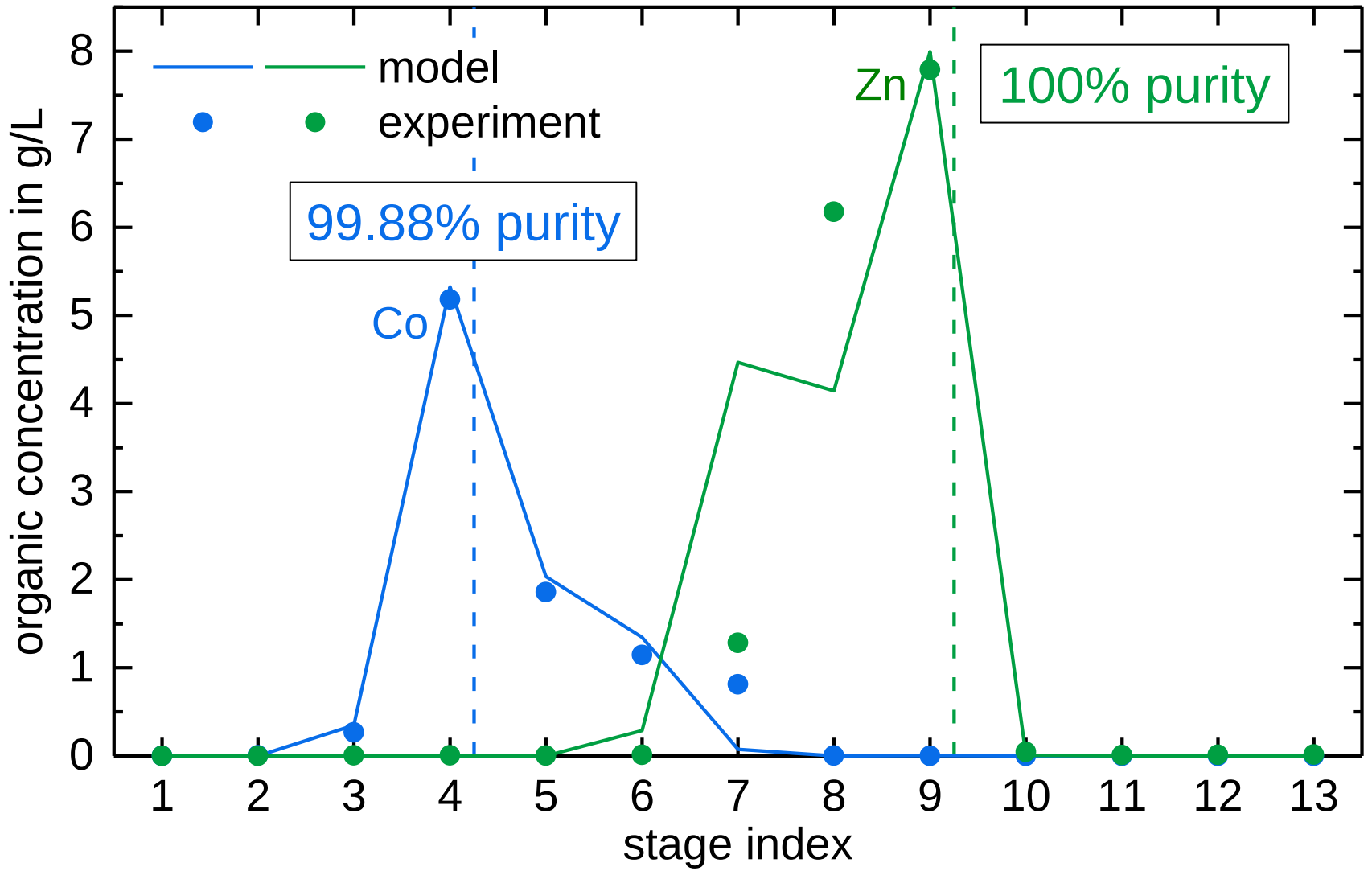
- before start



- after 5 residence times



experimental results



design equations

- inlet & removal streams,

  inlet concentration $\Rightarrow$ removal concentration

- overall *p*H-shift $\Rightarrow$ amount of base

- Tiller-Tour short-cut $\Rightarrow$ No. stages between two removals

take-home messages

- **single-process** to separate a **multi-component** mixture into **several product streams** of **arbitrary concentration**
- **accumulation zones**, one for each component, by controlling the **partition coefficients**
- process simulations, **validated experimentally**
- simple **design equations**
- patent PCT/EP2024/069959
- example applications
  - Li-ion batteries
  - neodymium magnets
  - electronic scrap
  - fermentation broth

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