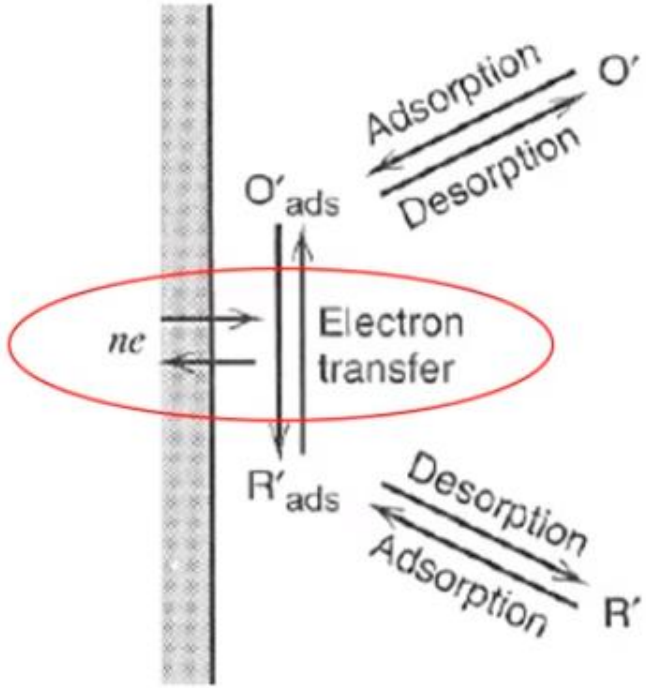
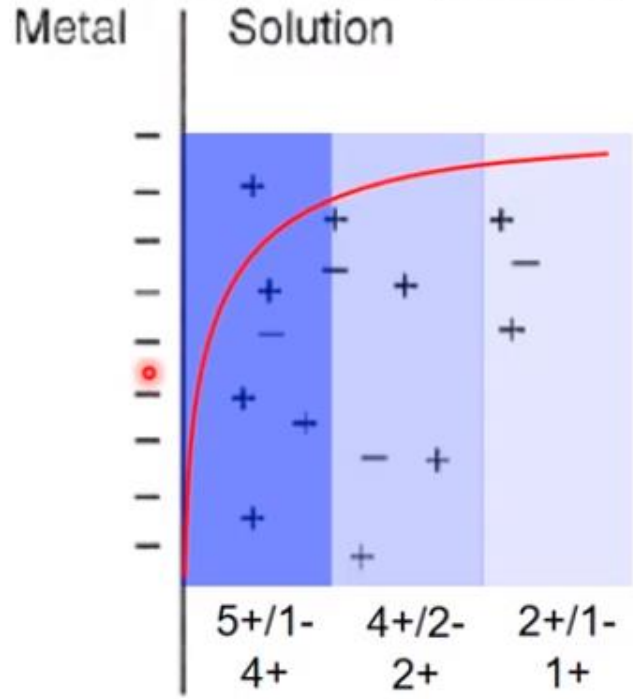
Faradaic versus Non-faradaic

Faradaic process or reaction



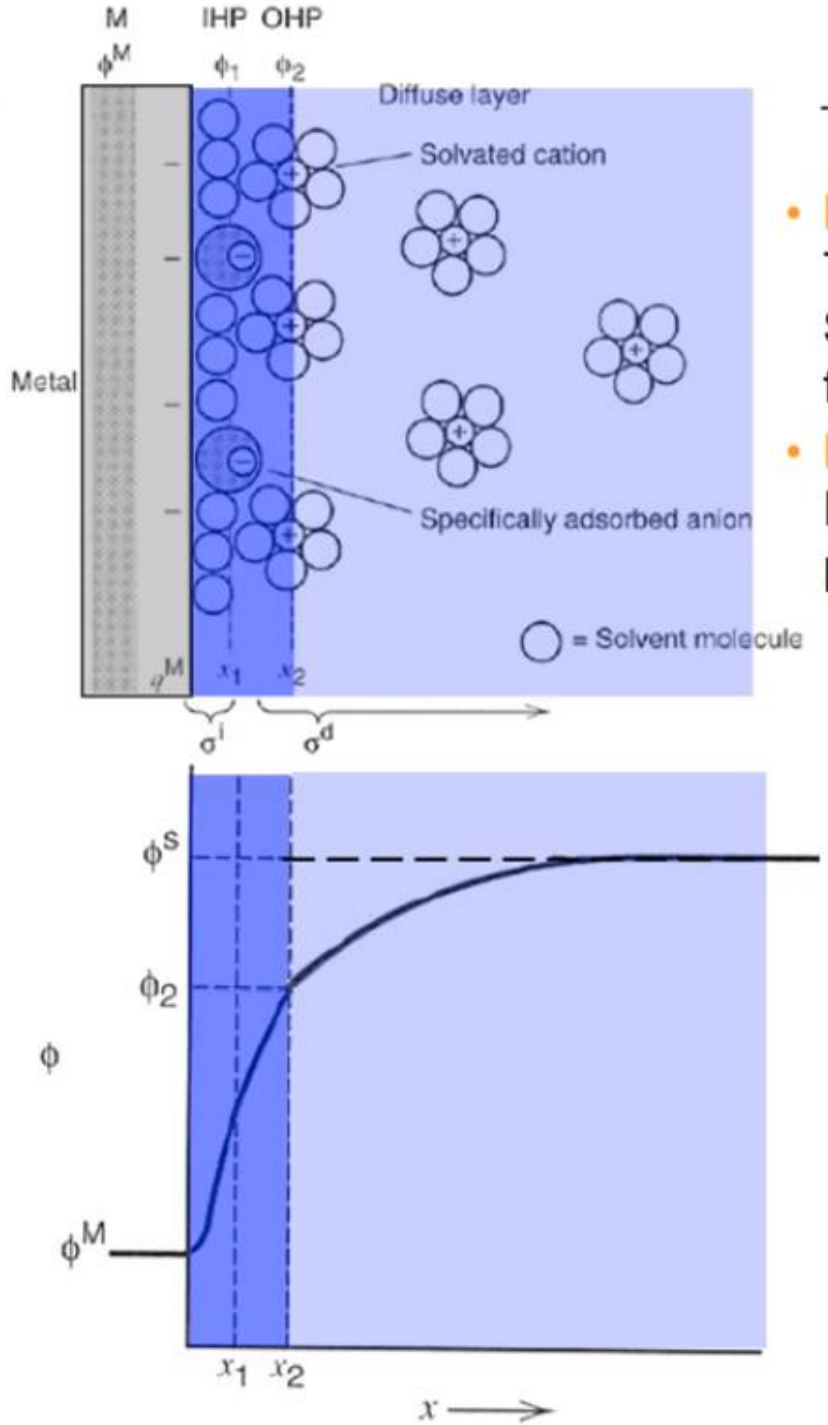
- Electron should pass the interface
- Driving chemical changes
- *Chemical reactions*

Non-faradaic process

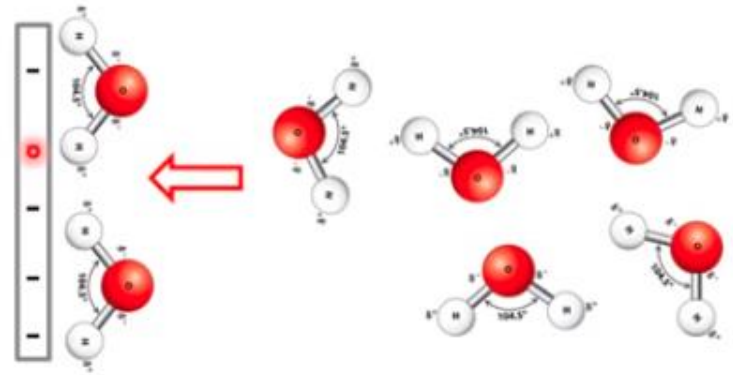


- Actually NOT lead to chemical changes
- Electrostatic forces btw different charges
- No electron can touch any species in electrolyte

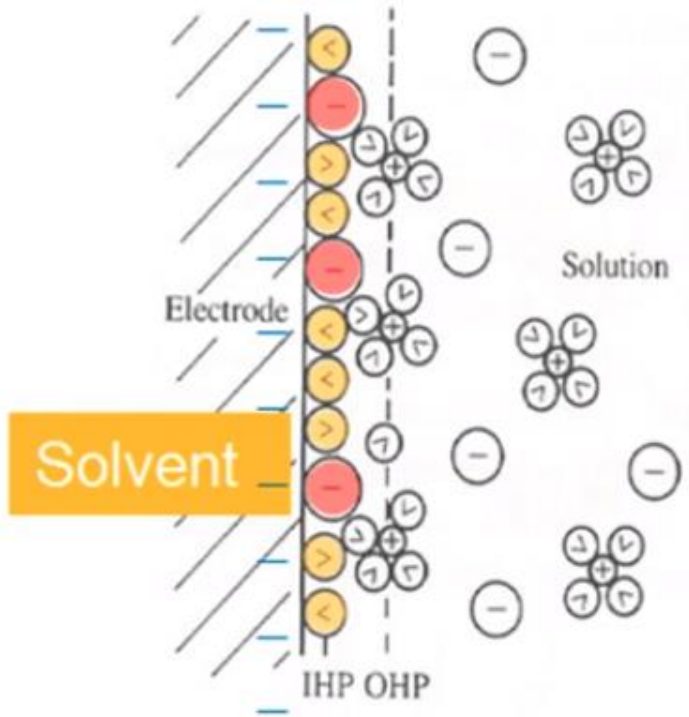
Electric double layer (EDL)



- **Helmholtz layer**:
  Two sub-layers just on surface.
  Solvent-molecular layer
  followed by the layer of **solvated counter-ions.**
- **Diffuse layer**:
  Distributed counter-ions compensate the rest of potential difference.



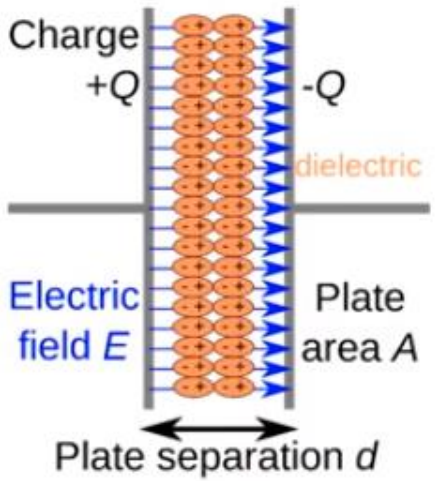
- EDLs are always developed even without applied potential.
- When a solid is immersed into a liquid, the reduction potential difference between the solid and the liquid drives the EDL formed.

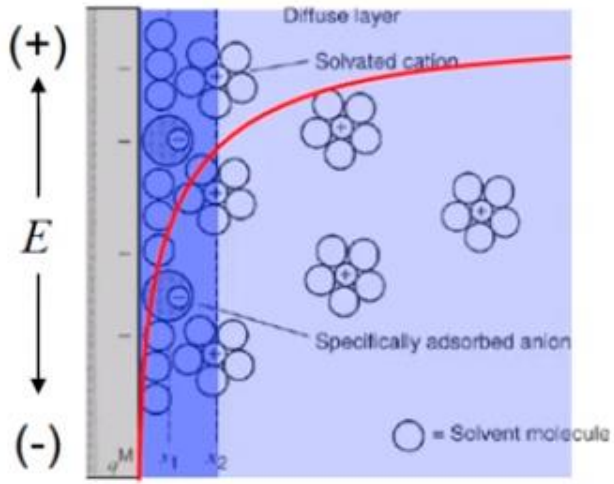


	Polarity
Solvent	Weak (Dipole)
Cation	Strong (Attractive)
Anion	Strong (Repulsive)
Specifically adsorbed species	Very Strong

Electric double layer (EDL)

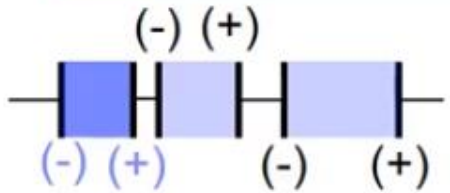
Electric double layers can be modeled by capacitors.





Capacitor

- A device that stores electrical energy in an electric field
- A dielectric material sandwiched between two metal plates
- One plate is positively charged while the other is negatively charged.
- Dipoles of the dielectric materials are oriented and re-arranged along the direction of applied electric field.

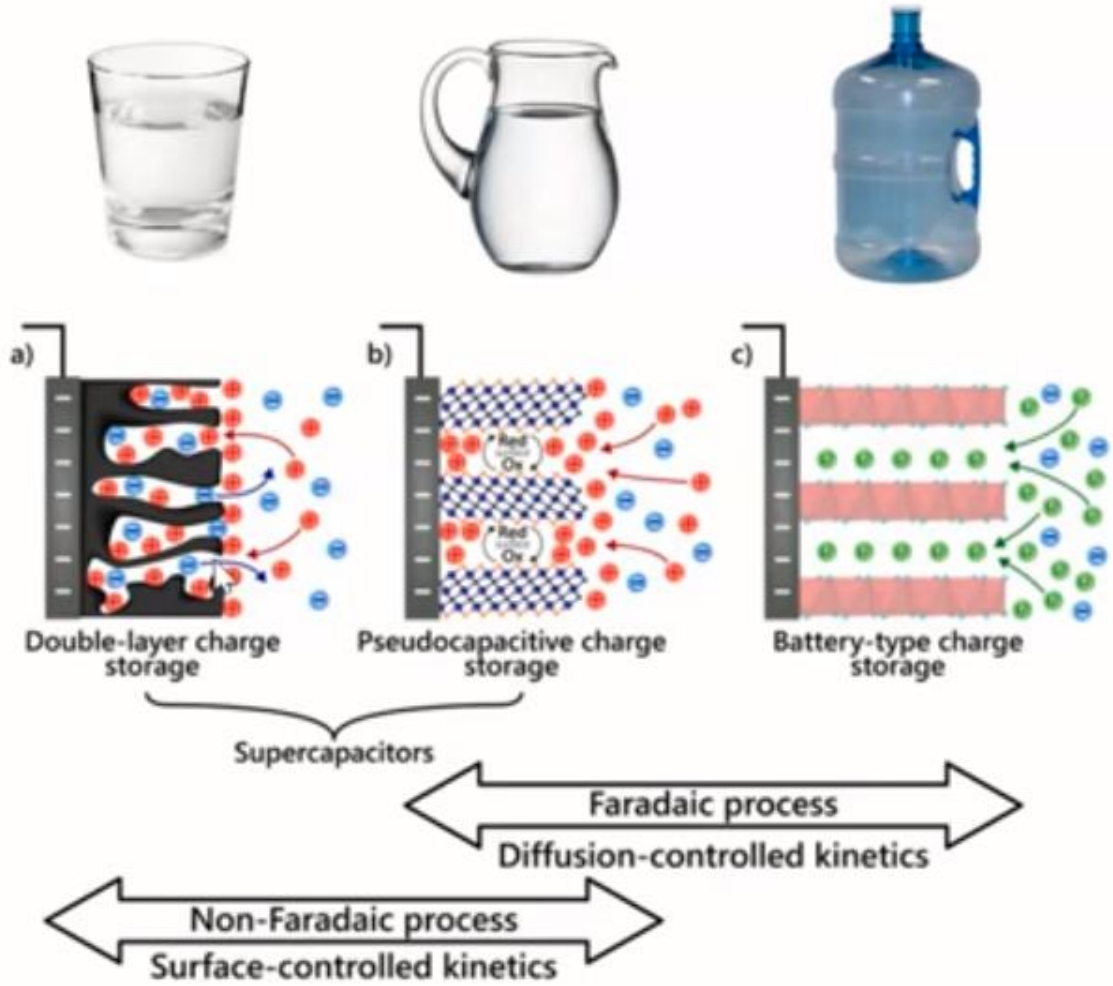


C_H $\quad 1/C_d = 1/C_{d,1} + 1/C_{d,2} + \ldots$

Helmholtz capacitor

$$1/C_{dl} = 1/C_H + 1/C_d$$

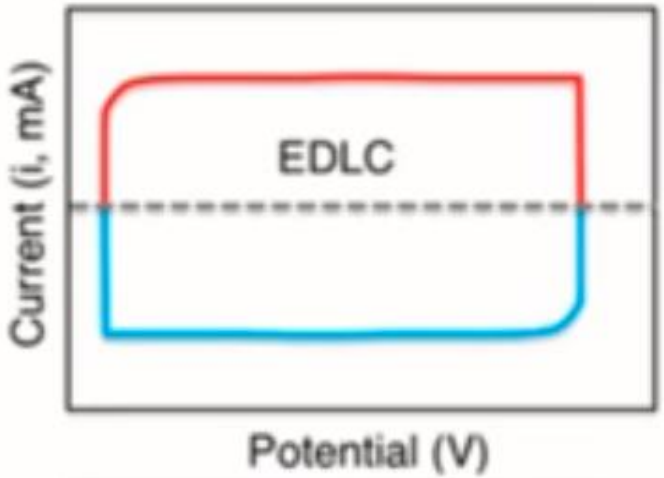
Electric double layer capacitance

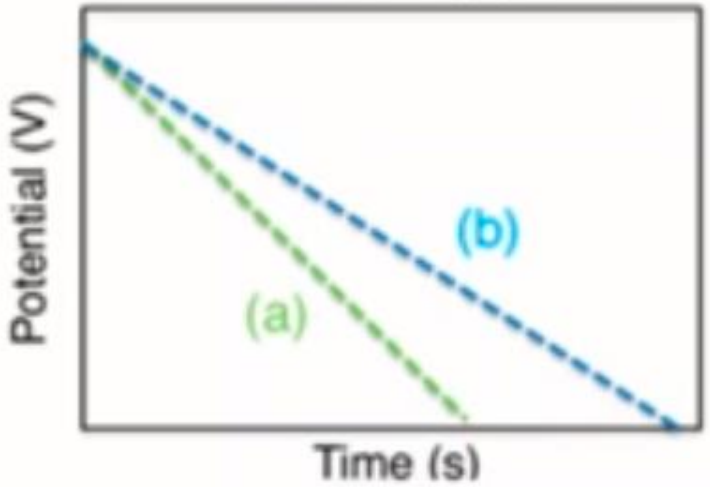


Mathis et al. Advanced Energy Materials, 2019, 9 (39): 1902007c

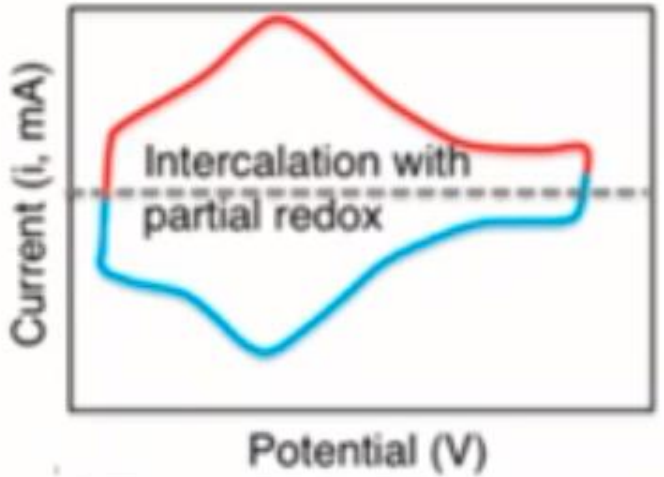
Types of Energy Storage

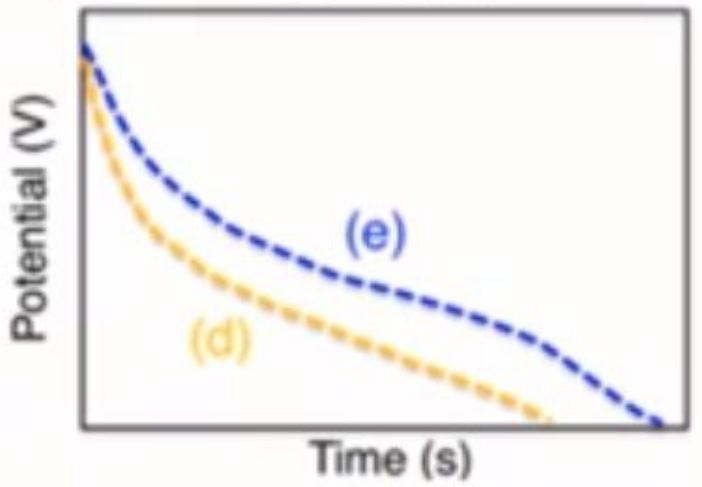
Electrical double layer capacitor



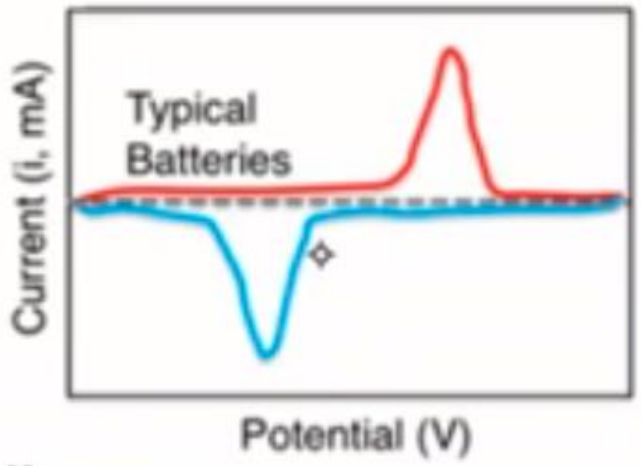


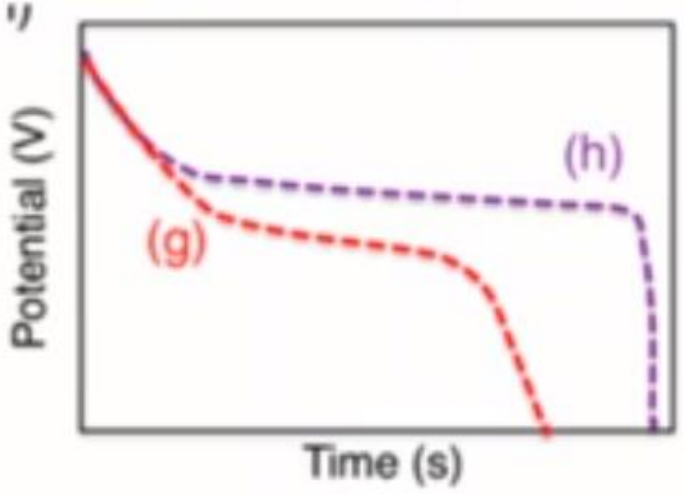
Pseudocapacitor





Battery





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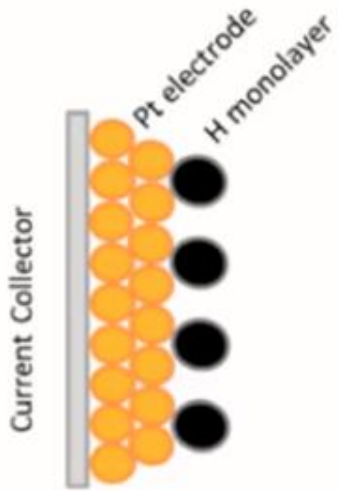
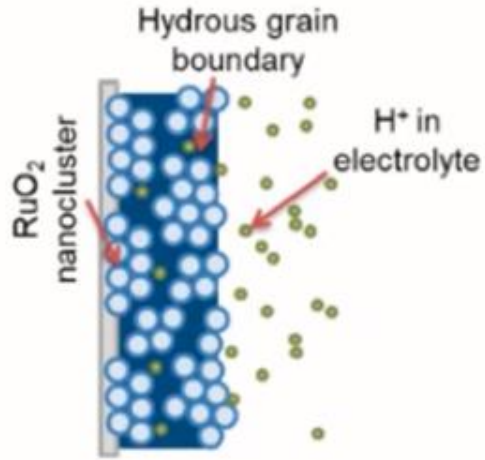
Types of pseudocapacitance

A **Adsorption Pseudocapacitance**



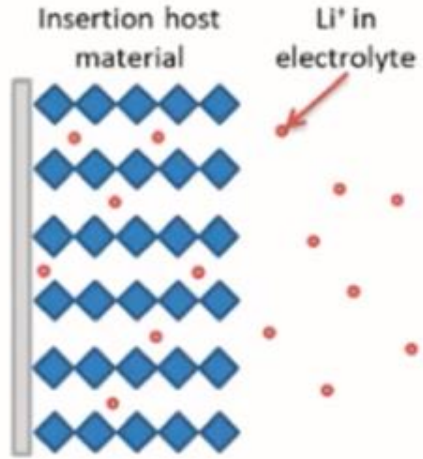
$$Pt + xH^+ + xe^- \leftrightarrow Pt{\cdot}xH_{ads}$$

B **Redox Pseudocapacitance**



$$RuO_2{\cdot}0.5H_2O + xH^+ + xe^- \leftrightarrow H_xRuO_2{\cdot}0.5H_2O$$

C **Intercalation Pseudocapacitance**



$$Nb_2O_5 + xLi^+ + xe^- \leftrightarrow Li_xNb_2O_5$$