



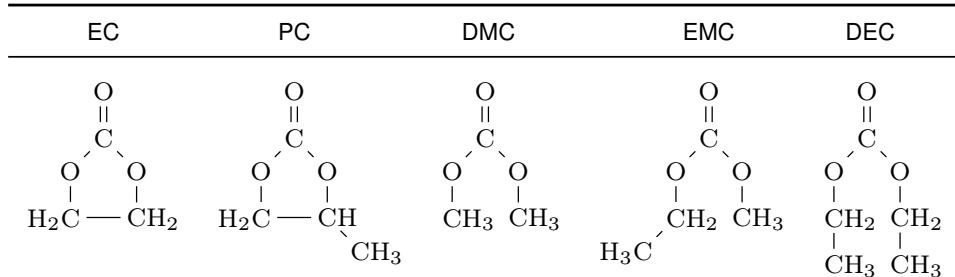
Electrolytes for lithium-ion cells

- We have now seen the most common materials used for negative and positive electrodes in lithium-ion cells
- We turn our focus to the principal remaining components, starting with electrolyte
- The electrolyte comprises a salt, acid, or base dissolved in a solvent and is the media that conducts ions between electrodes
- Cells using aqueous (solvent = water) electrolytes are limited to less than 2 V as water dissociate into oxygen and hydrogen in the presence of higher voltages
- Since their overall voltages are above 2 V, lithium-ion cells use electrolytes comprising non-aqueous organic solvents plus a lithium salt
- Electrolyte acts purely as ion conductor, not taking part in the chemical reaction



Electrolyte solvents used in lithium-ion cells

- Solvents include ethylene carbonate, propylene carbonate, dimethyl carbonate, ethyl methyl carbonate, diethyl carbonate



- A common feature to these solvents is the double-bonded oxygen, which develops a slight negative charge, polarizing the molecule so that it dissolves salts



Electrolyte salts used in lithium-ion cells

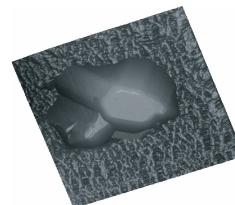
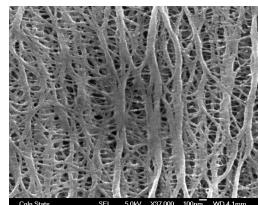
- The most commonly used salt in lithium-ion cells is LiPF₆ (Lithium hexafluorophosphate, which is quite difficult to say!)
- Some other candidates include LiBF₄ (lithium tetrafluoroborate) and LiClO₄ (lithium perchlorate)
- Note: the solvent does not participate in the (normal) chemical processes of a lithium-ion cell
 - But, different solvents have different properties re. aging, low-temperature performance, etc.
- So, we often refer to the electrolyte by naming only its salt, even though the electrolyte also includes solvent





Separators for lithium-ion cells

- The separator is a permeable membrane with holes large enough to let Li^+ pass through unimpeded, but small enough that the negative- and positive-electrode particles do not touch (which would short-circuit the cell); it is also an electronic insulator
- Looks like thin white plastic, but under magnification it is possible to see the pores



- Figure on right shows relative scale of one LMO particle on top of separator



Current collectors

- The inside of a lithium-ion cell is a very harsh environment, with Li and F being particularly reactive elements
- Need current collectors that will withstand that environment, such that they will not react with the electrolyte
 - Positive electrode (high potential region) uses aluminum foil, which does not react with electrolyte so long as cell voltage is above around 2 V
 - Negative electrode (low potential region) uses copper foil which does not react with electrolyte under similar conditions



Summary

- Lithium-ion electrolyte solvent is usually a combination of EC, PC, DMC, EMC, and/or DMC
- Electrolyte salt is usually LiPF_6 but is sometimes LiBF_4 or LiClO_4
 - PF_6^- anion is inert toward strong reducing agents, such as lithium metal
- Separator is a nonconductive porous membrane that prevents short circuits
- Current collectors are copper and aluminum foils



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