Development of Anode Materials for Sodium Ion Batteries

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Red Phosphorus as Anode for Na-ion Batteries:

**Advantage:**
- High theoretical capacity: 2593 mAh/g, P+3Na⁺+3e⁻ → Na₃P

**Challenges:**
- Intrinsically low electrical conductivity: 10⁻¹⁴ S/cm
- Large volume change

**Strategies:**
- **Increase conductivity:**
  Build nano-structure with high electronical conductive additives, like graphene, carbon nanotube (CNT), nanoporous carbon.

  **Accommodate large volume change:**
  Smaller particles: Ball mill large bulk red phosphorus particles into nanoscale.

  Cross-link binder: Build strong chemical bonds among phosphorus, functionalized carbon additive and binder, insuring a strong integrated structure from particle to electrode level.