

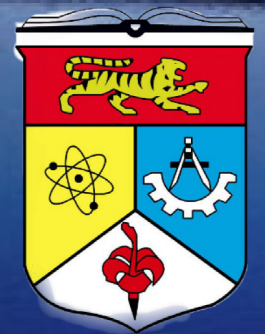
A review of key parameters for effective electrophoretic deposition in the fabrication of solid oxide fuel cells

Key words:

Solid oxide fuel cell, Electrophoretic deposition, Suspension stability, Zeta potential, Colloidal

Cite this as: Isyraf AZNAM, Joelle Chia Wen MAH, Andanastuti MUCHTAR, Mahendra Rao SOMALU, Mariyam Jameelah GHAZALI, 2018. A review of key parameters for effective electrophoretic deposition in the fabrication of solid oxide fuel cells. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 19(11):811-823.

<https://doi.org/10.1631/jzus.A1700604>



Solid Oxide Fuel Cell (SOFC)

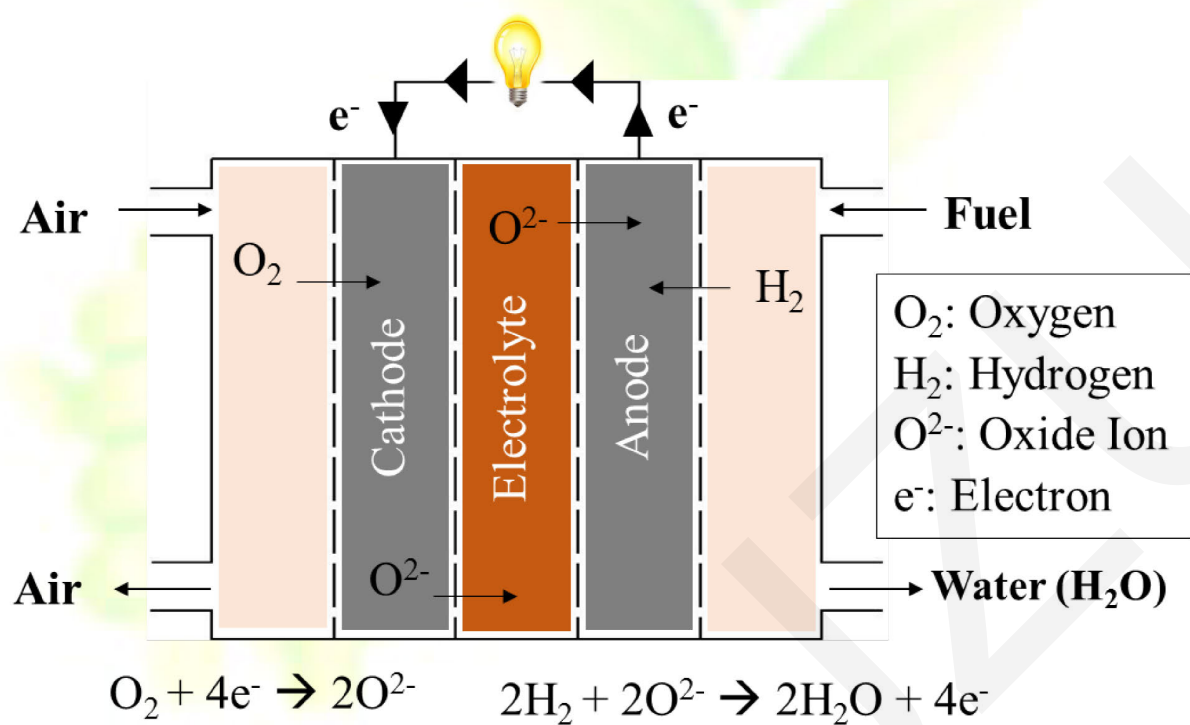


Figure 1. SOFC Operation Principle.

Electrochemical reaction $\xrightarrow{\text{without combustion}}$ Electrical energy

➤ Clean, reliable, efficient

Reduction of operating temperature to 400-800°C

Challenges:

- Increased polarization resistance
- High fabrication cost

Electrophoretic Deposition (EPD)

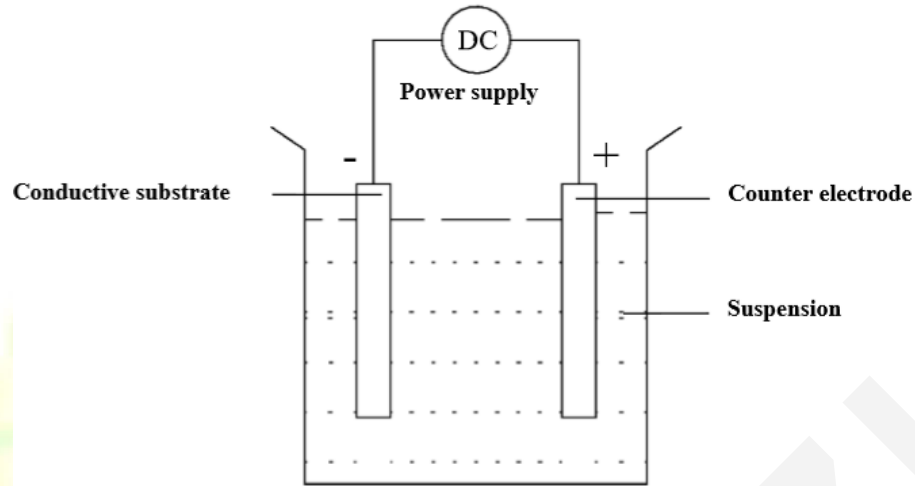


Figure 2. Schematic of cathodic EPD set up.

- **Uniform** layer deposition on complex geometry
- **Easy** control on layer thickness and morphology
- **Various** coating material combinations
- Environment **friendly** solvent
- **Standard** temperature and pressure process condition
- **Low cost** equipment

The charged particles form a layer on the negatively charged electrode in **anodic EPD** and on the positively charged electrode in **cathodic EPD**

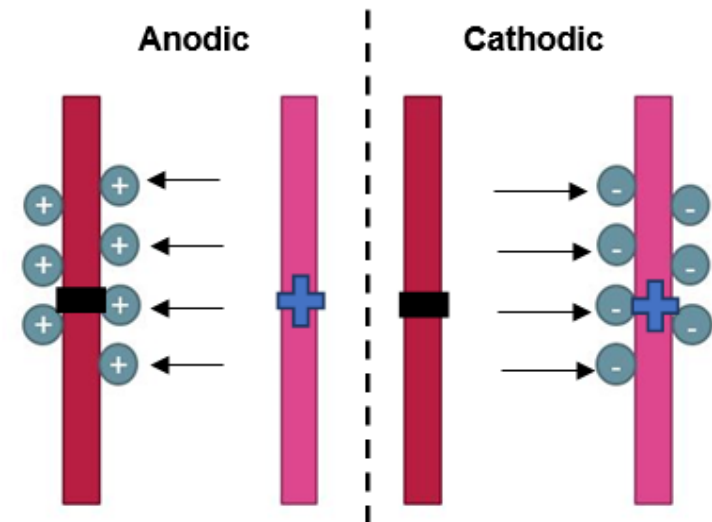


Figure 3. Electrophoretic Deposition Type:
(a) anodic and (b) cathodic.

EPD Mechanism

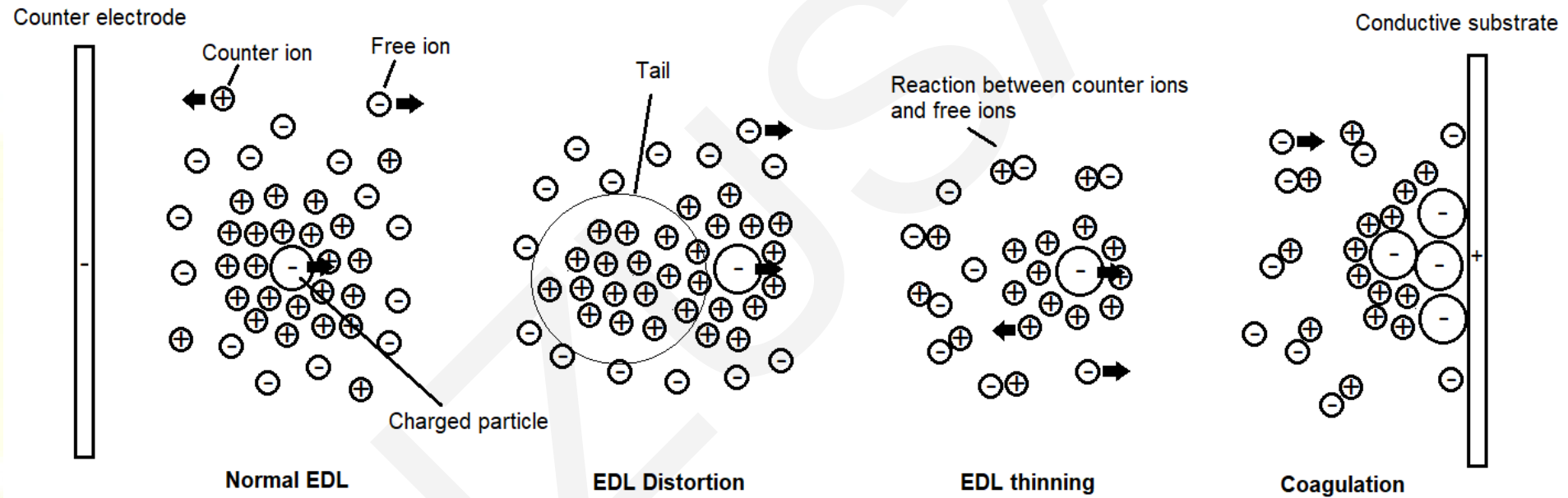


Figure 4. Illustration of the EDL distortion and thinning mechanism.

Keys for stable suspension

- Particle size
- Solid loading
- Dielectric constant
- Suspension conductivity
- Charging agent

Affects double layer region

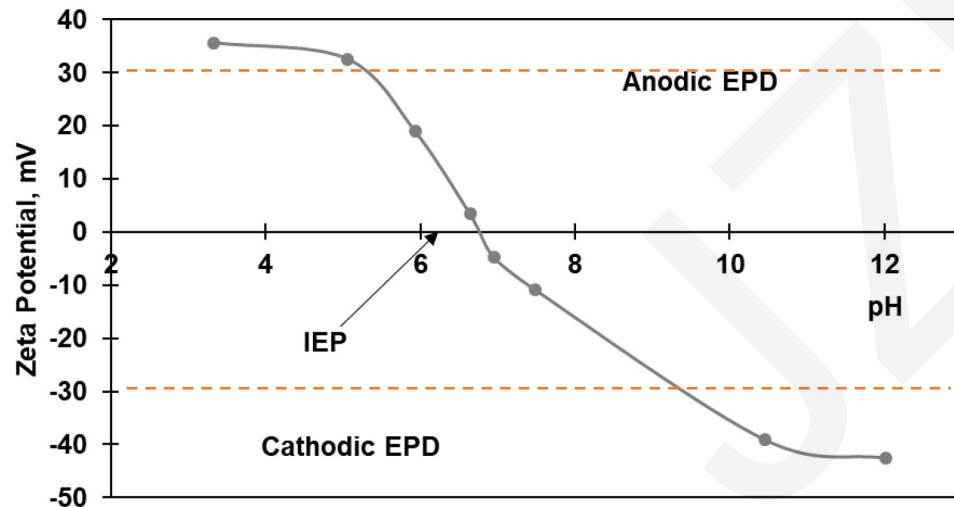
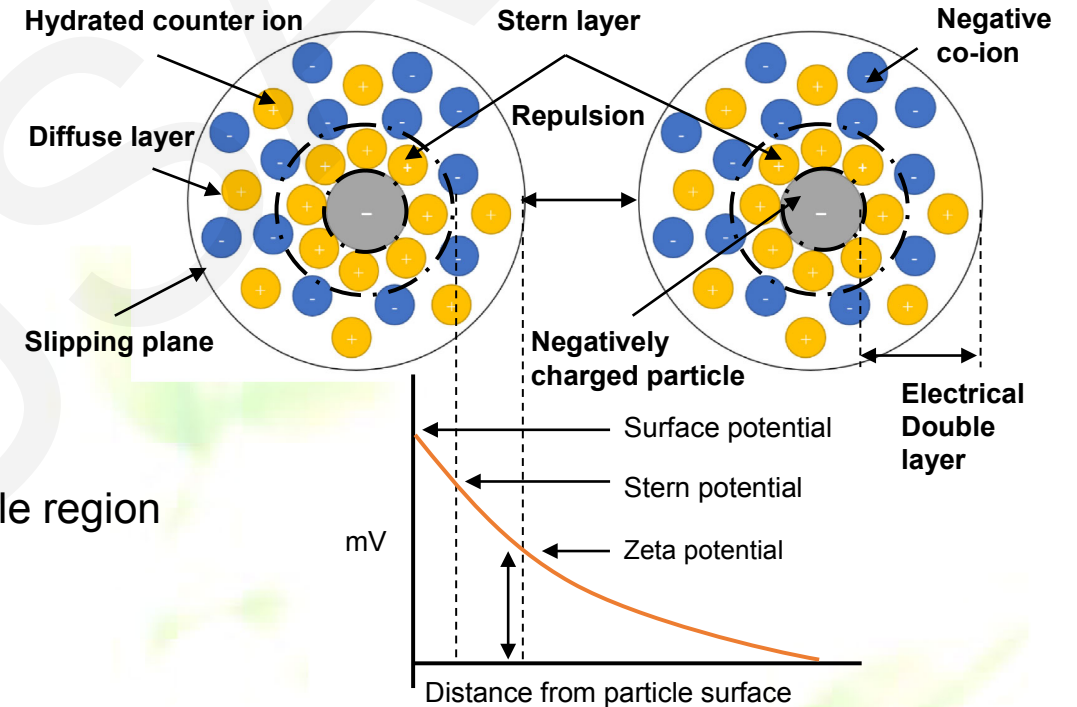


Figure 6. The isoelectric point of gadolinium-doped ceria suspensions in water. (López-Robledo et al., 2013)

Figure 5. Schematic of the double layer region of a particle.

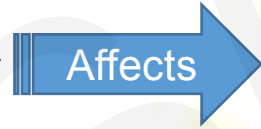
Affects zeta potentials

EPD Process Optimization

- Voltage applied
- Deposition time



Particle mobility



Mass deposited



Thickness

Density

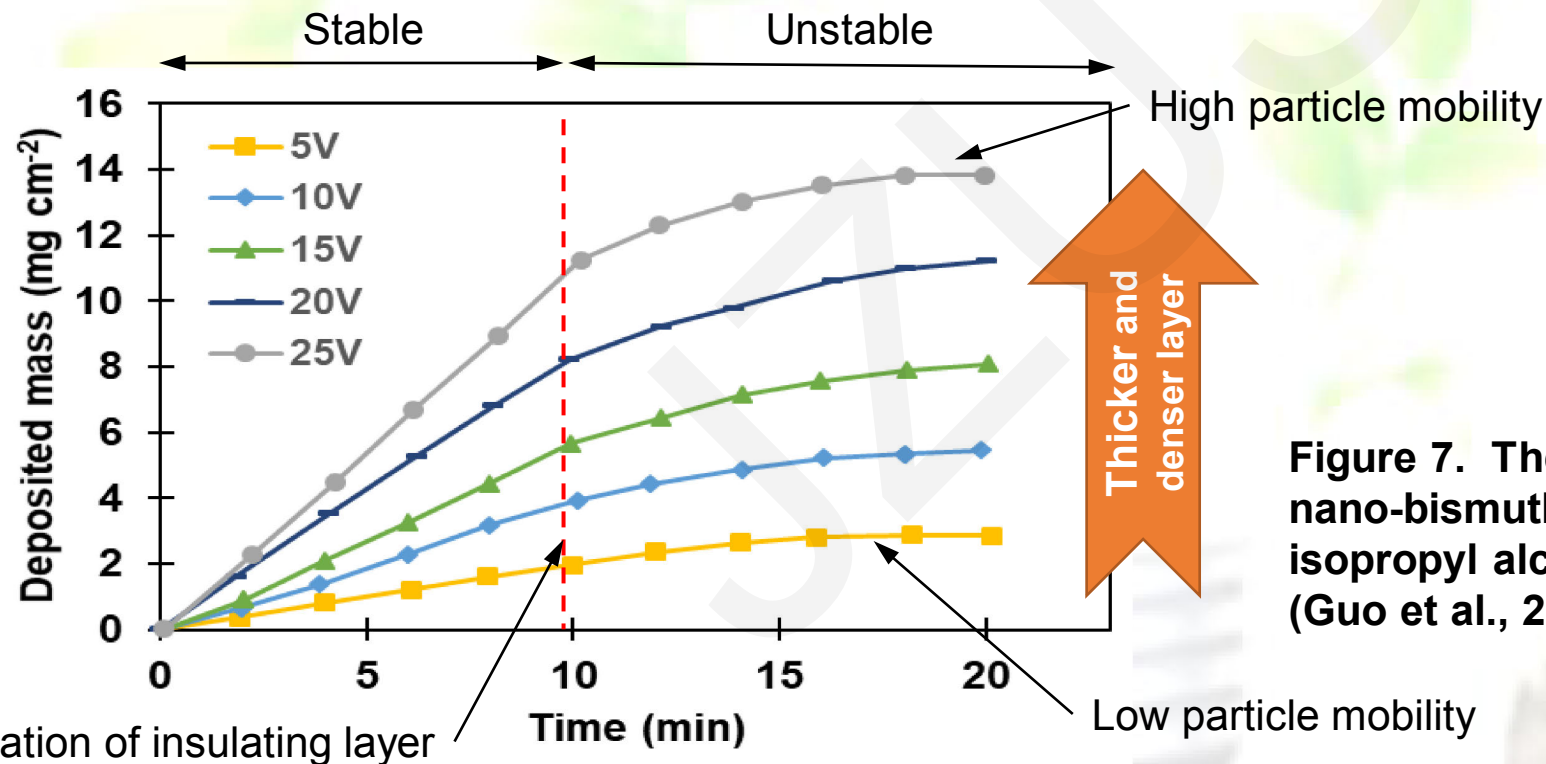


Figure 7. The electrophoretic deposition rate of nano-bismuth oxide (Bi_2O_3) suspended in isopropyl alcohol at various applied voltages (Guo et al., 2015)

Conclusions

- EPD technique facilitates the production of various SOFC designs with low fabrication cost.
- Suspension stability is key parameter for achieving successful deposition.
- Recent studies on key parameters to maintain suspension stability for SOFC applications, including the particle size and solid loading of the targeted coating material and the dielectric constant and conductivity of the suspension media, are highlighted in this paper.
- Particle mobility is determined by the combined effect of the above-mentioned parameters, which can be quantified through zeta potential measurements.
- Sufficiently high zeta potential is essential to ensure sufficiently mobilized particles for an effective EPD process. The zeta potential of a suspension can be tailored by manipulating its pH condition.
- Given that the layers of SOFC components involve various types of materials each requiring specific parameters to achieve effective deposition, careful preparation and optimization of the key parameters is essential to obtain the right recipe for each type of SOFC material.