Cellulose as a Pore Former in Electroless Co-Deposited Anodes for Solid Oxide Fuel Cells

EUROPEAN FUEL CELL FORUM

Edinburgh Napier UNIVERSITY

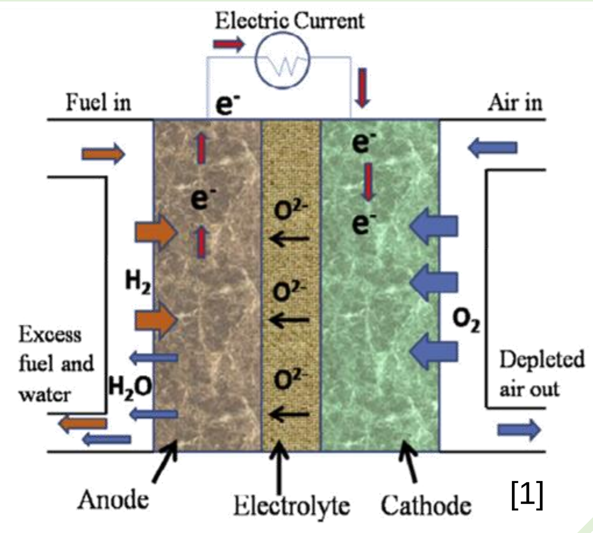
Introduction

Solid Oxide Fuel Cells

Solid Oxide Fuel Cells (SOFC) produce electricity via the oxidation of a gaseous fuel [1].

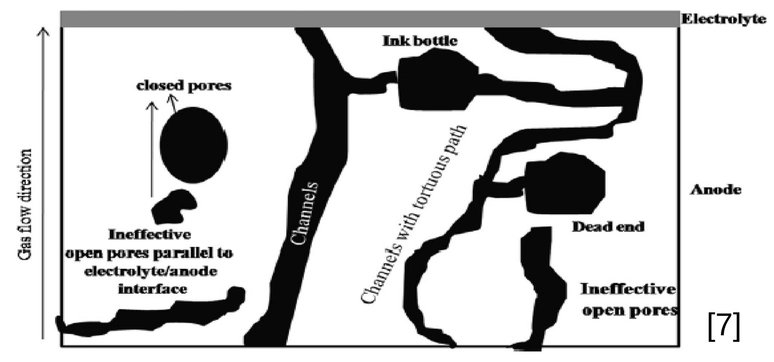
Therefore, electrodes are required to have a porous structure to allow for the diffusion of fuel gases to the reaction sites within the electrodes [2].

As a result, pore formers are used to produce porous electrodes to improve fuel cell performance [1].



[1]

Porosity



[7]

An interconnected pore network will provide greater opportunity for the fuel gas and resultant waste gases to diffuse in (and out) as well as increasing the triple phase boundaries within the electrode, producing a SOFC with a higher power density [1].

Cellulose Pore Formers

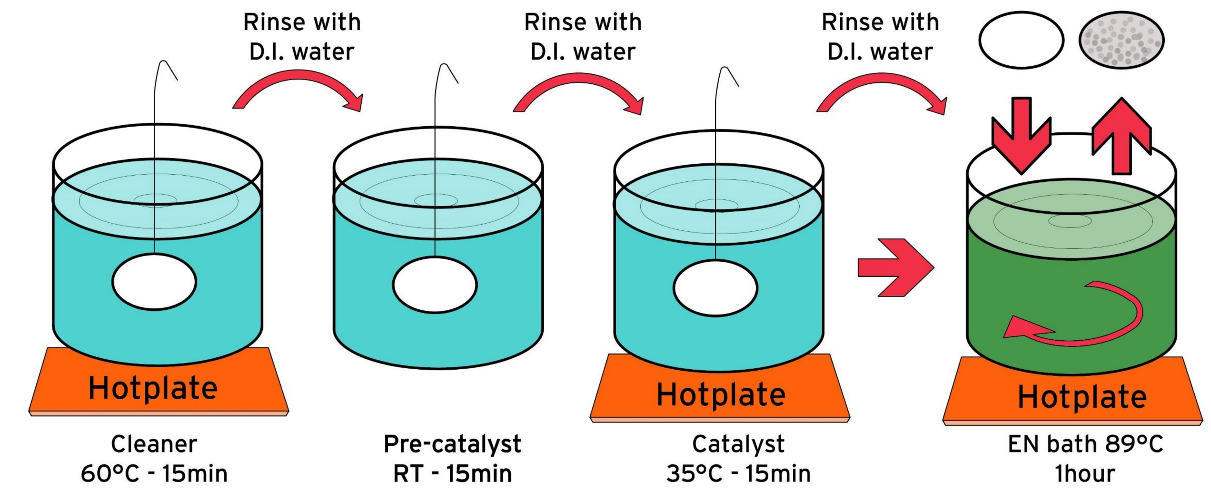
As the choice of pore former is closely related to the type of pores they produce, a more fibrous pore former will have a greater chance of producing a more interconnected porous network than a spherical one [6].

Particle Fibre Fibrous

Cellulose comes in many different sizes and morphologies and is one of the most abundant biopolymers on earth. Its insolubility in water, low temperature pyrolysis and low cost makes it an excellent candidate to use as a pore former in the manufacture of SOFC electrodes via Electroless Co-Deposition [6].

Manufacturing Technique

Edinburgh Napier University has patented a new manufacturing process, which uses Electroless Co-Deposition to produce SOFC electrodes faster and cheaper than current methods using just 4 simple steps [3][4][5].

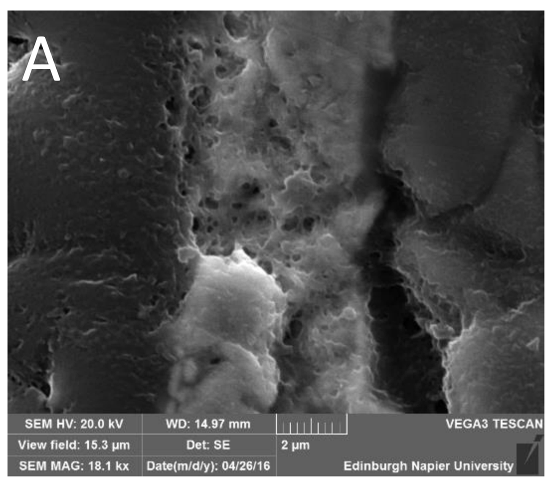


Methodology

Materials Used		
Name	**Size**	**Morphology**
Sigmacell	20µm	Particle
Avicel PH 101	50µm	Particle
Tencel	100µm	Fibrous
Knife Milled Cellulose	200µm	Fibrous

1. **Select suitable Cellulose samples by their size and morphology**
2. **TGA of Cellulose samples to determine their thermal properties**
3. **Use ECD to produce samples of each pore former**
4. **Removal of pore former from one of each sample via pyrolysis**
5. **Use Mercury Porosimetry to determine porosity**

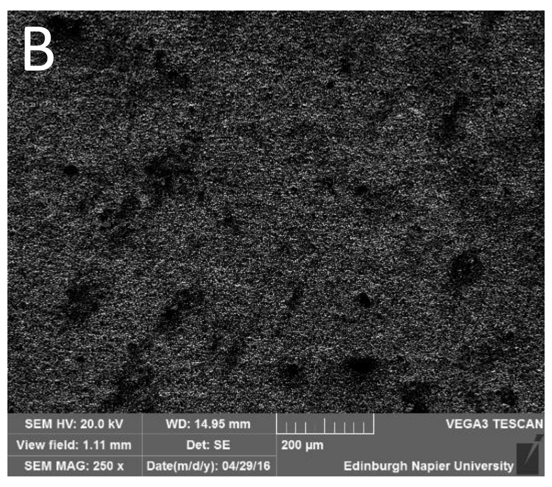
Results and Conclusions

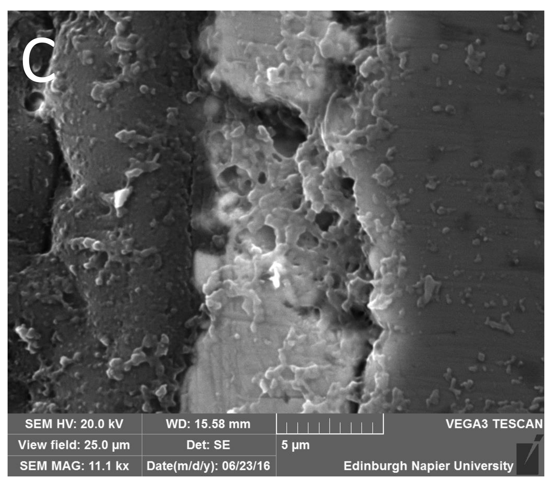


Sigmacell

A) Cross Section
- Highly porous cross section with visibly interconnected pores

B) Surface
- Abundant pore openings with an overall rougher surface

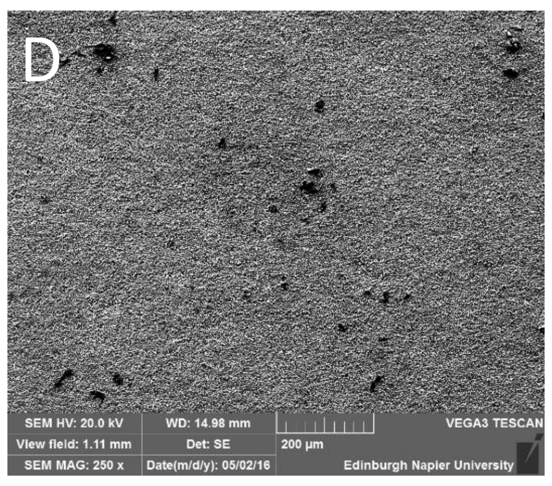


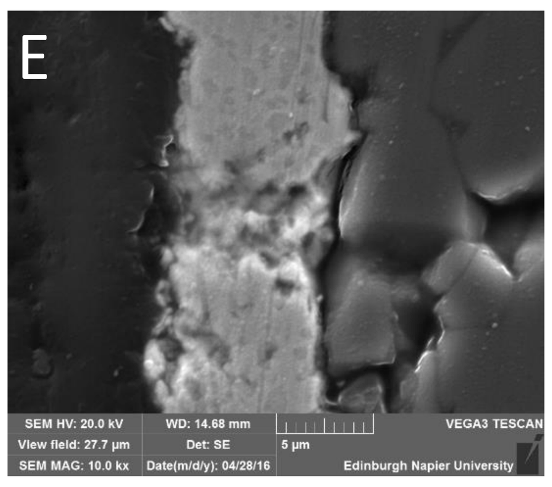


Avicel PH 101

C) Cross Section
- Porous cross section with some signs of interconnected porosity

D) Surface
- Smooth surface with numerous pore openings

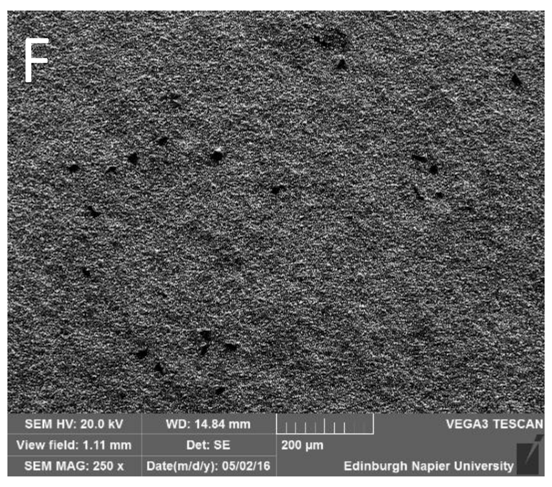


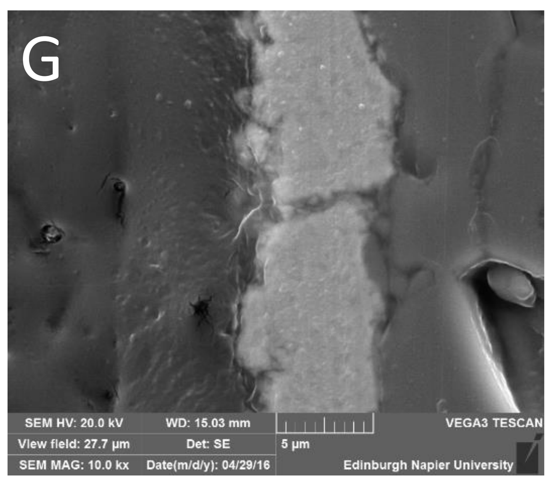


Tencel

E) Cross Section
- Large pores with little interconnectivity

F) Surface
- Rough surface with few pore openings

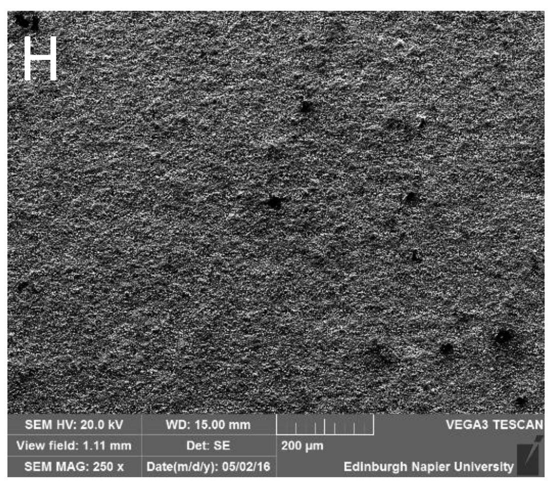




Knife Milled

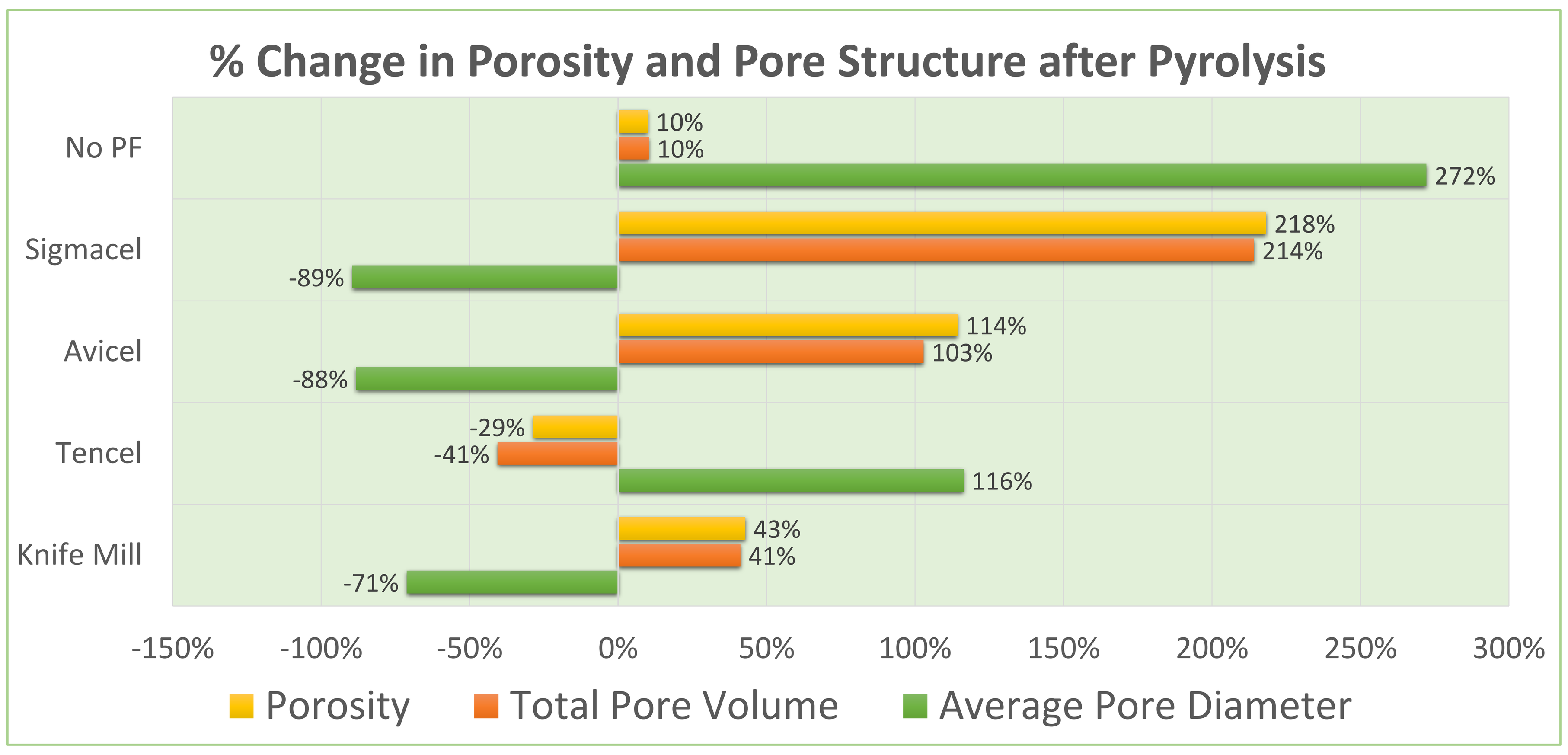
G) Cross Section
- Few pores in coating with little to no interconnectivity throughout

H) Surface
- A small number of pore openings on surface



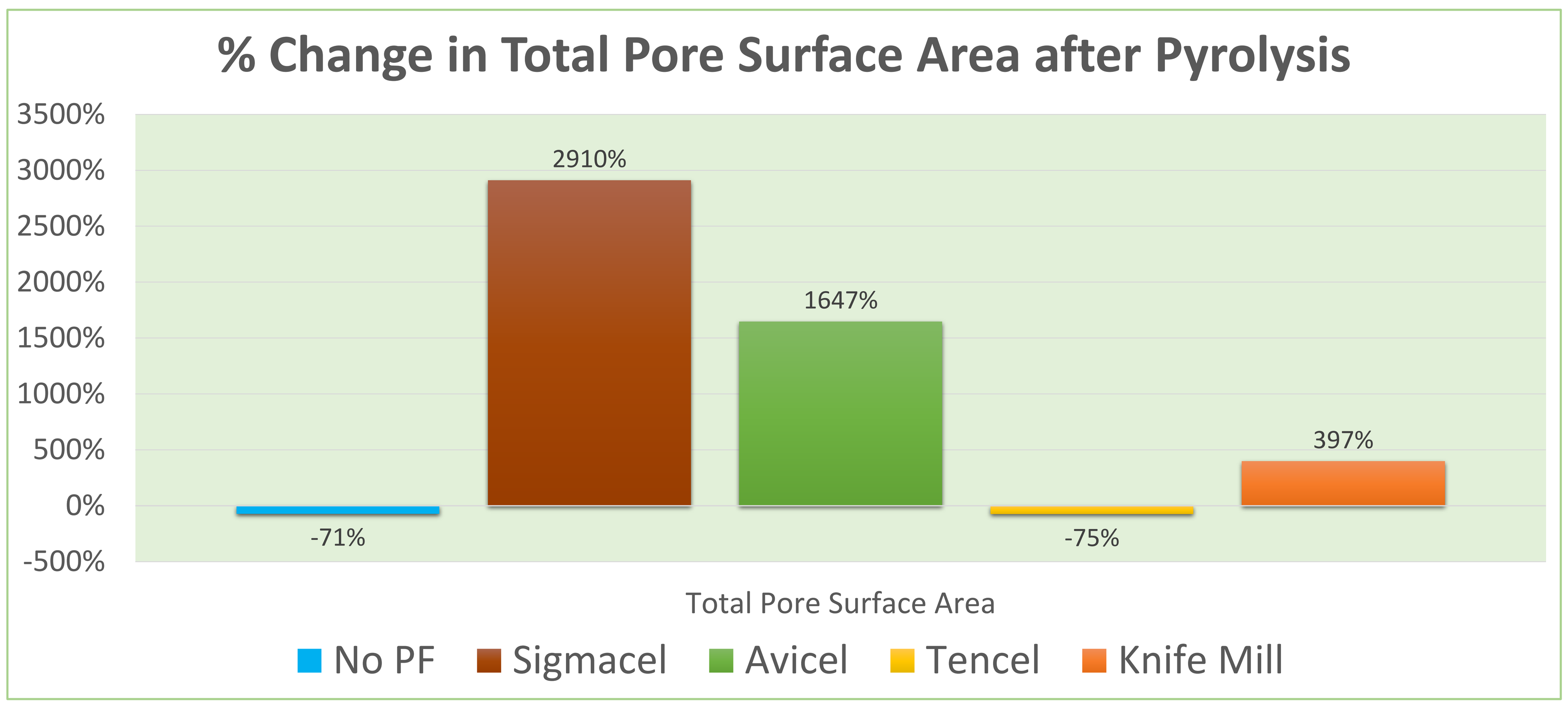
Conclusion

- The Cross Sections of the coating showed that the smaller cellulose pore former had a greater impact on the coating microstructure. It produced more perpendicular pores as well as greater interconnectivity between them than the larger sizes.
- The surface images also showed that the smaller pore former produced more surface openings than the larger pore formers. This was shown by conducting an EDS of the surface and looking for peaks in carbon located around the pore openings.
- This increase in perpendicular pores and greater pore interconnectivity will allow for more of the gaseous fuel to diffuse through the electrode and produce a greater power density when used in a SOFC electrode.



Conclusion

- Sigmacell had the greatest impact on porosity and microstructure. More material was able to be incorporated within the coating due to its smaller size and therefore produced a more porous coating upon its removal.
- Tencel produced the opposite effect to all other pore formers, decreasing the porosity and total pore volume. However it did increase the average pore diameter within the coating.
- This increase in porosity and total pore volume will allow more of the fuel and waste gases to diffuse in and out of the electrode producing an overall greater power density.



Conclusion

- Sigmacell had the greatest impact on the total pore surface area, increasing it by 2910%.
- This gain in pore volume will increase the available triple phase boundaries within the electrode. By increasing the available reaction sites, more reactions will be able to occur simultaneously, causing an increase in power density when used as an electrode within a SOFC

References

[1] MAHATO, N., BANERJEE, A., GUPTA, A., OMAR, S. & BALANI, K. 2015. Progress in material selection for solid oxide fuel cell technology: A review. *Progress in Materials Science,* 72**,** 141-337.

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