Hematite (α-Fe₂O₃) is an abundant, n-type semiconductor which offers good thermal stability in aqueous mediums. It has a small indirect bandgap of 1.9~2.2 eV which makes it favourable for applications in photoelectrochemical (PEC) water splitting [1]. Due to its stability and abundance, hematite has been used for various applications such as the manufacturing of gas sensors, lithium batteries, pigments, photocatalyst and as photo anodes in PEC water splitting for hydrogen production [2]. Stability and abundance, hematite has been used for various applications such as the PEC water splitting [1]. Due to its stability in aqueous mediums. It has a small indirect bandgap of 1.9~2.2 eV which makes it favourable for applications in photoelectrochemical (PEC) water splitting [1]. Due to its stability and abundance, hematite has been used for various applications such as the manufacturing of gas sensors, lithium batteries, pigments, photocatalyst and as photo anodes in PEC water splitting for hydrogen production [2].

**Materials and Experimental Procedure**

- **Iron (III) nitrate nonahydrate** (Fe(NO₃)₃.9H₂O, Sigma Aldrich, GC, 99%); then heated at 110 °C for 2.5 hrs, forming a brick red mass of iron(III) oxide (C₆H₇FeO₃).
- After each layer, the dip coated substrate was annealed at 500 °C for 1 hr, to form α-Fe₂O₃ crystals. The procedure was repeated four times in order to produce four layers of α-Fe₂O₃ thin film.
- The precursor solution was synthesized by dissolving 50 mM of iron(III) nitrate (Fe(NO₃)₃) in 200 ml of deionized water. The precursor solution was synthesized by dissolving 50 mM of iron(III) nitrate (Fe(NO₃)₃) in 200 ml of deionized water.
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**Preparation of hematite nanoparticles**

- The precursor solution for dip coating was prepared by mixing a 2:1 mol ratio of iron(III) nitrate nonahydrate (Fe(NO₃)₃.9H₂O, Sigma Aldrich, AR, 99%) and oleic acid (C₆H₇O₂, Sigma Aldrich, GC, 99%) then heated at 110 °C for 2.5 hrs, forming a brick red mass of iron(III) oxide (C₆H₇FeO₃).
- After each layer, the dip coated substrate was annealed at 500 °C for 1 hr, to form α-Fe₂O₃ crystals. The procedure was repeated four times in order to produce four layers of α-Fe₂O₃ thin film.
- The precursor solution was synthesized by dissolving 50 mM of iron(III) nitrate nonahydrate (Fe(NO₃)₃.9H₂O, Sigma Aldrich, AR, 99%) into 200 ml of deionized water.
- After four layers of spray-pyrolysis, the substrate was annealed at 500 °C for 1 hr, forming four layers of α-Fe₂O₃ thin film.

**Results and Discussion**

**Fig. 2.** (a) Morphology of hematite thin film prepared by dip coating, (b) Morphology hematite nanoparticles prepared by dip coating, (c) Morphology of hematite thin film prepared by spray-pyrolysis, (d) Morphology hematite nanoparticles prepared by spray-pyrolysis.

- Both films absorbed light in the visible region with the onset range of 590 nm to 610 nm. Fig. 3(b), Fig. 3(a), Fig. 3(b)
- After each layer, the dip coated substrate was annealed at 500 °C for 1 hr, to form α-Fe₂O₃ crystals. The procedure was repeated four times in order to produce four layers of α-Fe₂O₃ thin film.
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**Fig. 3.** (a) XRD planes of α-Fe₂O₃ films prepared by dip coating and spray-pyrolysis, (b) Raman spectra of α-Fe₂O₃ nanoparticles prepared by dip coating and spray-pyrolysis.

- The grain size was determined with Average Grain Intercept (AGI) as 50.00 nm for the dip coating film indicating agglomerated nanoparticles.
- The two main peaks corresponding to the (104) and (110) Miller indices were present confirming the hexagonal rhombohedral structure of hematite. The remaining unindexed intense peaks were due to the FTO substrate. The average crystal sizes of 11.5 nm and 15.45 nm were obtained from the Debye-Scherrer formula, for dip coating and spray-pyrolysis, respectively.
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**Fig. 4.** Absorbance spectra of films prepared by (a) dip coating and (b) spray-pyrolysis. The inset shows the absorbance of both the α-Fe₂O₃ samples.

- Optical studies performed by UV-Vis indicated that samples prepared by spray-pyrolysis showed slightly better absorbance. This could be attributed to grain size, as smaller grain size reduces grain boundaries which reduces the distance that light needs to travel in order to be absorbed.
- It was also noted that the spray-pyrolysis samples had a smaller bandgap which is indicative of better absorption.
- This study suggests that the various nanoparticle production methods, as well as annealing repetition can influence the structural integrity of hematite thin films.

**Conclusions**

- Optical studies performed by UV-Vis indicated that samples prepared by spray-pyrolysis showed slightly better absorbance. This could be attributed to grain size, as smaller grain size reduces grain boundaries which reduces the distance that light needs to travel in order to be absorbed.
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**References**