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A Review on Synthesis and Properties of Graphene-TiO_2 Nanocomposites for Perovskite Solar Cells

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INTRODUCTION & AIM

The development of perovskite solar cells (PSCs) using sustainable green nanomaterials has indeed shown great promise in the renewable energy sector due to its high efficiency, low manufacturing cost, and potential for commercial viability. However, there are some issues that need to be addressed to make PSCs available commercially for development of the sustainable technology. These issues include stability, toxicity, scalability, and reliability. In this context, titanium dioxide (TiO_2) have been widely investigated as an electron transport layer (ETL) in PSCs due to its promising properties includes high refractive index and strong UV absorption due to wide band gap of ~3.2eV . However, despite these advantages, TiO_2 also has some limitations, such as poor charge transport properties, high rate of electron-hole recombination, stability problems and poor visible light response which lower the current and voltage densities of the solar cell. Researchers have explored optimizing the morphology of TiO_2 with graphene nanomaterials which can help in enhancing the performance and stability of PSCs because of its exceptional electrical conductivity, high electron mobility, large surface area, and excellent mechanical properties. This review summarizes the research going on in the field of synthesis, structural, morphological, optical, photovoltaic properties of graphene based TiO_2 nanomaterials reported by different authors across the globe as an ETL for PSCs.

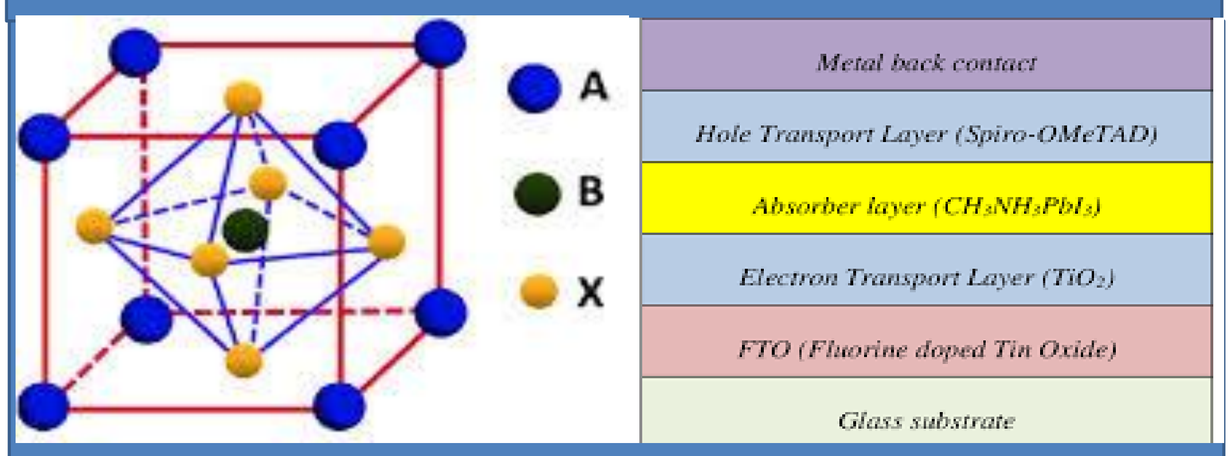


Figure 1. (a) Structure of Perovskite Materials & Perovskite Solar cells

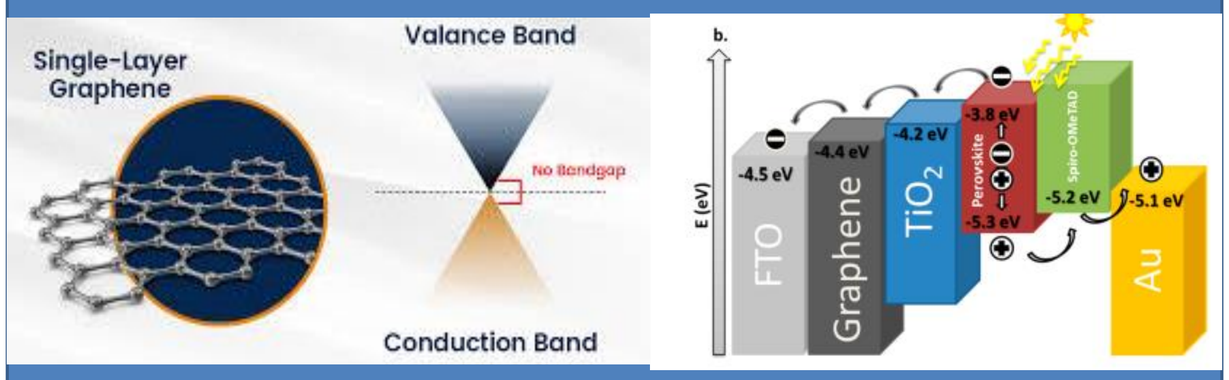
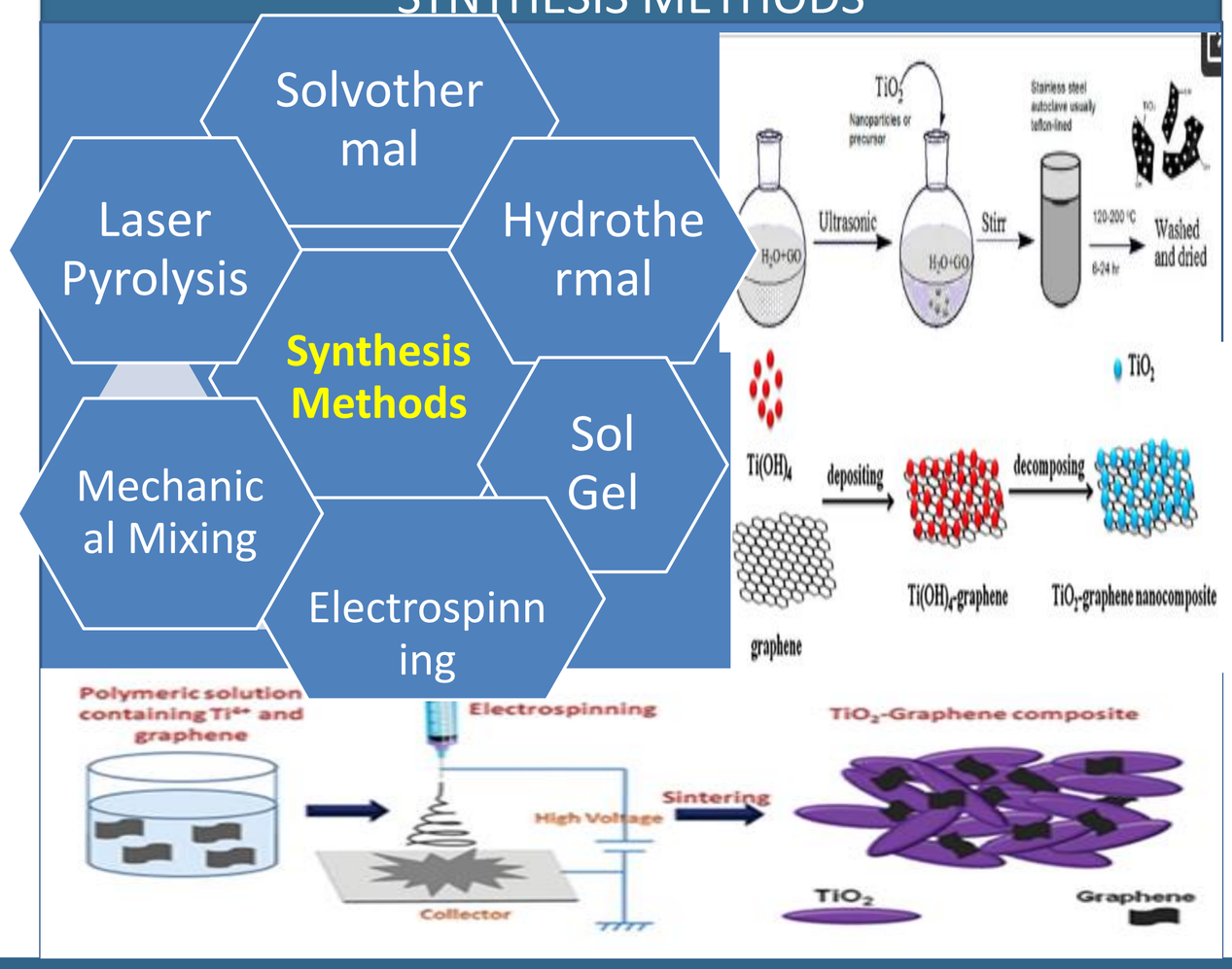


Figure 2. (a) Structure of Graphene (b) Energy levels of the materials in g-TiO_2 based Perovskite solar cell [1]

SYNTHESIS METHODS



RESULTS & DISCUSSION

Morphological Properties of graphene- TiO_2 Nanocomposites

- SEM/TEM show well-dispersed graphene in TiO_2 matrix
- Increased surface coverage → better charge extraction
- Fewer traps → reduced recombination losses
- Improved light absorption and film uniformity
- Graphene improves film morphology leading to dense, pinhole-free layers, larger grain sizes and fewer trap states.

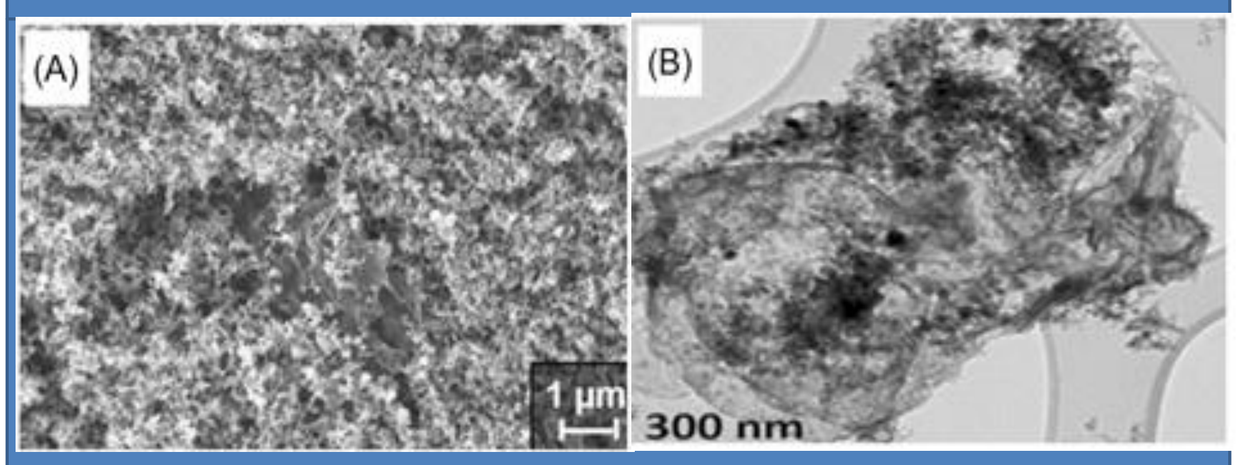


Fig. 3. (A) SEM image of TiO_2/graphene nanocomposite (B) TEM image of TiO_2/ graphene nanocomposite by laser pyrolysis [1]

Photovoltaic & Structural Properties of graphene- TiO_2 Nanocomposites Perovskite Solar Cells

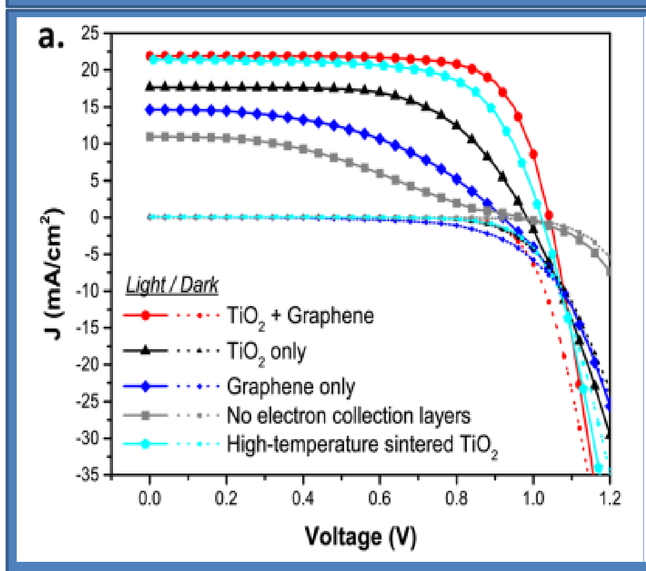


Fig. 4, I-V characteristics of various ETLs in Perovskite solar cell at simulated AM 1.5 solar at 100mW/cm² (solid line), and dark (dotted line) [1]

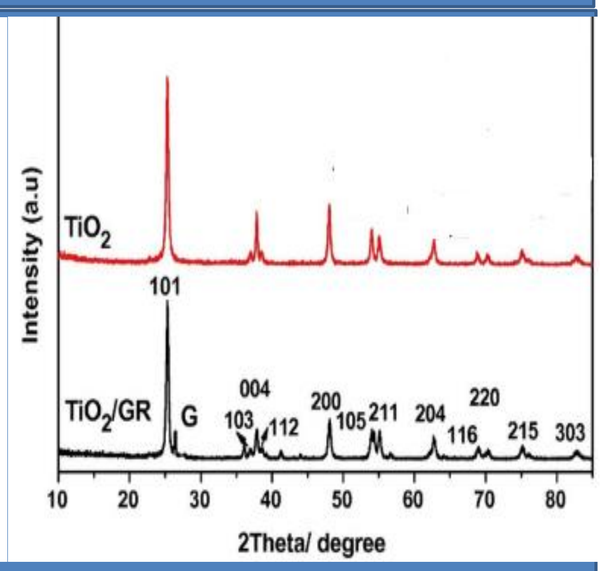


Fig XRD images of TiO and TiO_2/graphene nanocomposites synthesized by laser pyrolysis method [2]

CONCLUSION

- g-TiO_2 addresses critical PSC issues: stability, surface morphology, conductivity, and efficiency.
- Graphene-TiO_2 nanocomposites used in perovskite solar cells exhibit enhanced electrical and structural properties, leading to improved device efficiency and stability compared to pure TiO_2 layers.
- Synthesis method plays crucial role in final device performance.
- Continued research is needed for scalable, reproducible processes.

FUTURE WORK / REFERENCES

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