Dye Sensitized Solar Cells combined with Surface Plasmon Effect

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Introduction

One of the challenges concerning the fabrication of efficient dye sensitized solar cells is improving the DSSC light harvesting[1]. In this work we have studied the effect of a gold nanoparticles (AuNP's) layer over the TiO_2 mesoporous film before the dye absorption and another layer on the top of the mesoporous TiO_2 film already coated with dye, both attempts to increase the light absorption via surface plasmon effect.[2] By controlling the nanoparticles diameter, surface plasmons can be generated within the visible region hence improving light entrapment and the ability of the dye to absorb light.

Objectives

The main goal of this work was studying the surface plasmon effect over DSSC efficiency, considering the increase in light absorption of organic molecules nearby metallic nanostructures. In addition, studying effect of this layer on the electrical parameters of a dye sensitized solar cell.

Experimental Procedure

TiO_2 nanoparticles were obtained by the hydrolysis of titanium isopropoxide. The growth of the nanoparticles is obtained under hydrothermal conditions in a autoclave, leading to the formation of TiO_2 nanoparticles with average size distribution, of *ca.* 20 nm. The TiO_2 was sensitized by dipping the mesoporous film in a $3x10^{-4}$ M solution of the sensitizer N-719. This dye is well known for presenting large absorption spectra and fast electron injection to the conduction band of TiO_2.[3]

Gold nanoparticles with 16 – 23 diameter were prepared by reducing gold (III) chloride in sodium citrate solution. The devices were assembled as earlier described in the literature.

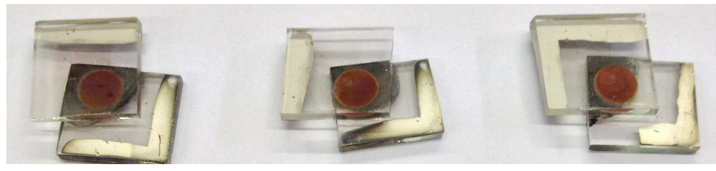

Figure 1. Assembled dye sensitized solar cells.

Results and discussion

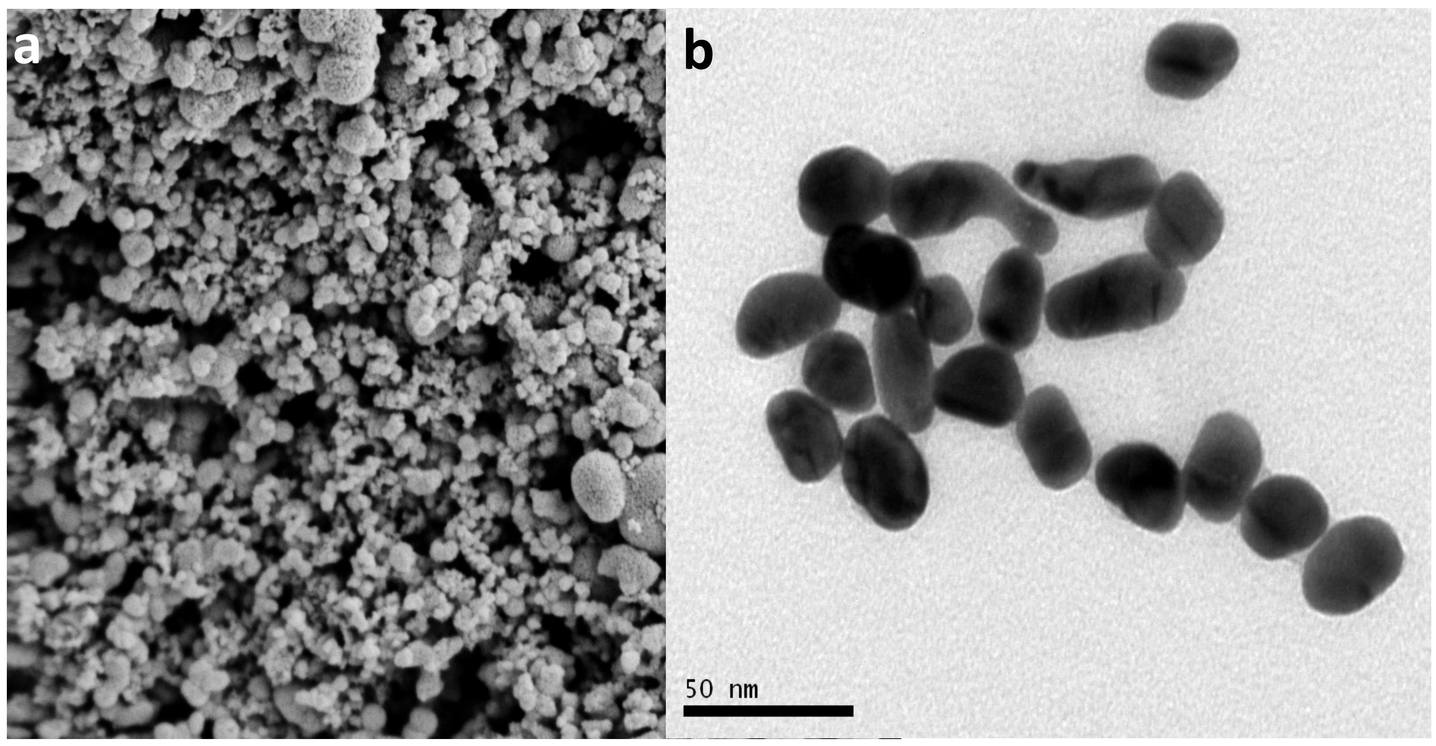

Figure 2. (a) SEM image of TiO_2 mesoporous film; **(b)** TEM image of gold nanoparticles **(c)** absorption spectra of the gold nanoparticles and the sensitizer N719.

According to the results, devices assembled with gold nanoparticles deposited over the TiO_2 layer before sensitization show nearly same efficiency as the standard DSSC, however the Fill Factor (*FF*) of this sample was lower. This result suggest that the presence of AuNP's affect the dye/TiO_2 interaction. On the other have, an interesting result was obtained in the device where the AuNP's were deposited on the top of the dye, a 28% improvement in efficiency was observed. Based on this results, we can suggest that the plasmonic materials are very important to the DSSC due to it light absorption effect, mainly when combined directly with the dye.

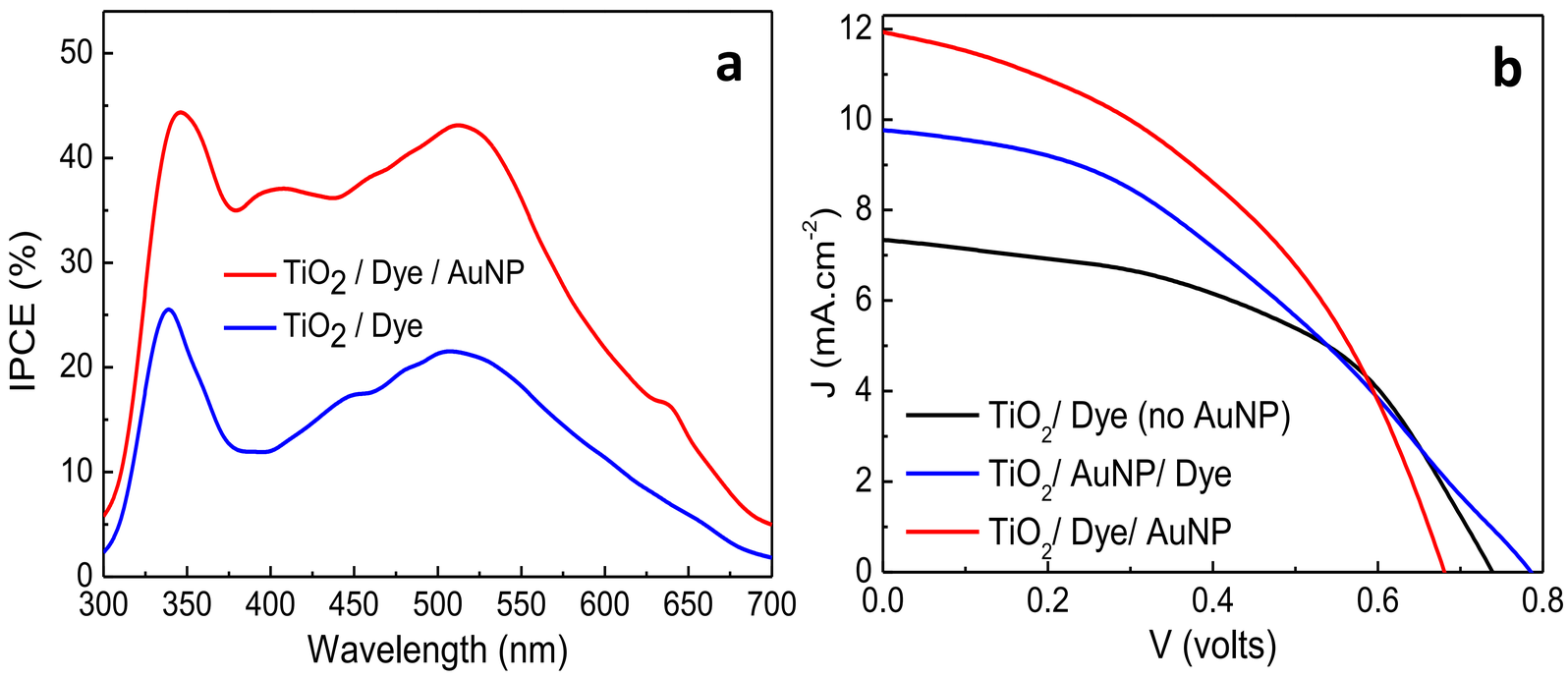

Table 1. Characterization parameters of the cells

	I_{sc} (mA)	V_{oc} (V)	*FF* (%)	η (%)
No AuNP	**7.3**	**0.74**	**50**	**2.7**
TiO_2/AuNP/Dye	**9.8**	**0.79**	**38**	**2.9**
TiO_2/Dye/ AuNP	**11.9**	**0.68**	**43**	**3.5**

Figure 3. (a) IPCE measurement of the studied DSSC's; (b) Current *versus* potential curves: red is related to AuNP deposited after sensitizing the TiO_2, blue represents AuNP deposition before sensitization, and black is the standard DSSC.

Conclusion

Preliminary results show devices achieving about 3% efficiency. The presence of gold nanoparticles increases the generation of electron-holes pairs, improving mainly the photocurrent and device's efficiency even with the decrease of the *FF*.

References

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[2]S. Muduli, N. Valanoor, S. B. Ogale, *Solar Energy,* ***2012, 86, 1428***
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