Unraveling the correlation between structure and performance by optical techniques on Organic Solar Cells

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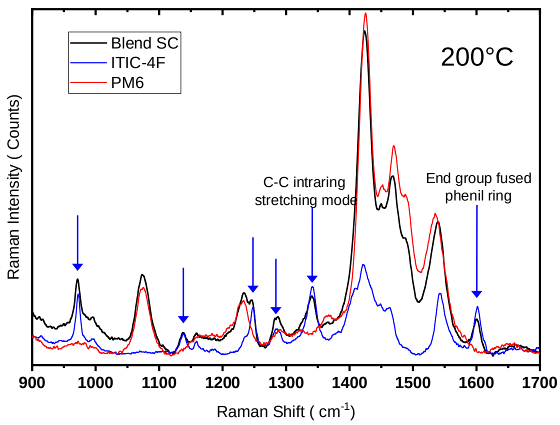
During last years, PV efficiency of organic solar cells (OSC) has dramatically increased, and nowadays approaches the 20% threshold with a 19.5%. Furthermore, OSCs have shown special promise working on indoor conditions, achieving a 28% of efficiency and proving a better adaptability for these conditions than traditional PV devices. This breakthrough in performances has been partially obtained thanks to the development of novel non fullerene acceptors (NFA) and corresponding donor polymers. Nevertheless, many aspects of these materials have to be yet explained for a successful transfer of the technology into industrial scale.

Among other things, it has already been proven the importance of the structure of the active layer for obtaining high performances. Most techniques used for determining the structuration of the active layer are time consuming and normally require samples prepared for the experiment, like TEM or GDRX. In this work we propose Raman scattering for analyzing the structure of the active layers on OSC. Raman scattering is an optical technique, non-destructive and does not require any special preparation of the sample. Furthermore, it can be used in whole solar cells as well as in single layers. Also, time measurements are normally in the range of minutes. Finally, raman scattering allows a finer in-depth analysis, with the help of confocal measurements we can obtain results from different depths and compare the structuration, while on XRD measurements, the whole bulk of the layer is measured and there is no means to separate the signal by its origin in the sample.

In order to demonstrate this, we present the analysis of the ITIC-4F/PM6 blend as a function of the annealing temperature and compare the spectra obtained from these active layers with the spectra of pure ITIC-4F and PM6. We compare these results with the ones obtained by GRDX and then discuss the correlation between the final devices performance and the degree of organization of the active layers.



Raman spectra for PM6 (red), ITIC-4F(blue) and the active layer (black) annealed at 200°C. Blue arrows mark the peaks corresponding to ITIC-4F that appear on the active layer spectrum.