Modification of Pentacene Thin Films with Benzene-1,4-Diboronic Acid in Supercritical Carbon Dioxide

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Abstract

This research investigates the effect of different processing parameters on the treatment of organic thin film semiconductor, such as pentacene, using supercritical carbon dioxide ($scCO_2$) in presence of a potential molecular modifier. Pentacene is chosen due its high potential for producing flexible organic thin film transistors, which can be used in various electronic devices including chemical sensors[1-3]. Benzene-1,4-diboronic acid (BDBA) is selected as a molecular modifier in this work because of its electron deficient nature, which can potentially enhance pentacene physical, chemical or electronic properties, by changing its structure in the solid state. All experiments are performed inside a custom-made 316 stainless steel, high-pressure cell with calcium fluoride used as optical windows[4]. The solubilities of BDBA in $scCO_2$ are first characterized and compared at two different temperatures with up to 5 mol % methanol used as co-solvent, using ultraviolet absorption spectroscopy. The results show that at 323 K, BDBA solubility increases as a function of fluid density and co-solvent amount, similarly to the solubility trend previously observed at 313K[4]. However, BDBA solubility increases by more than three folds when $scCO_2$ solution temperature decreases from 323 K to 313 K, with methanol co-solvent amount held constant at 4.6 mol %. Pentacene thin films, with different thicknesses, are then treated with BDBA in $scCO_2$ solution with methanol used as co-solvent under two different temperatures. Reflectance infrared spectroscopy is used to characterize pentacene thin films. BDBA solubility appears to be the main indicator for how much BDBA can be absorbed into pentacene film surface rather than processing temperature alone. The amount of BDBA absorbed/adsorbed on pentacene film surface is found to increase as film thickness increases. The majority of BDBA detected on pentacene film surface is believed to be resulted from BDBA molecular diffusion from $scCO_2$ solution into the film during treatment. However, there is also some suggested evidence that a small amount of BDBA is deposited on film surface through physical dispersion of BDBA particles during the depressurization process of the high-pressure cell.

References

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