Cyanine dye ionic junctions for organic electronics

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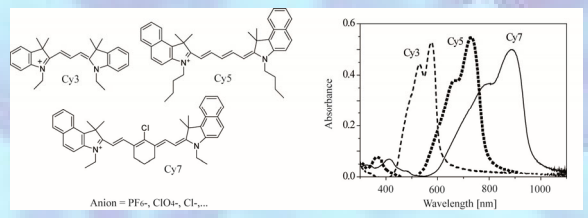
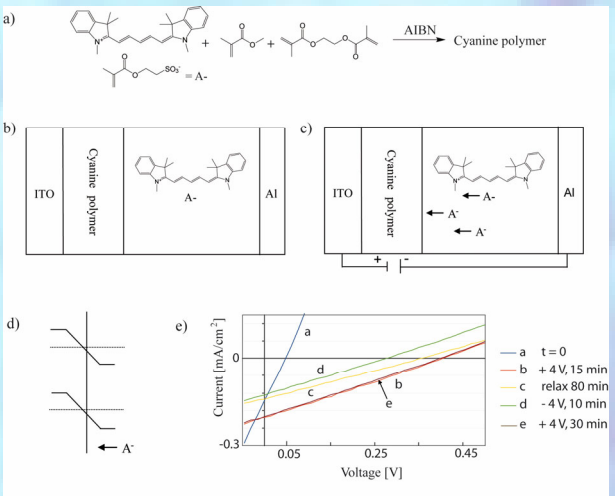
Background

Significant process is being made with organic small molecules and polymers that feature mixed ionic / electronic conduction for new applications in the fields of optoelectronics, sensors and smart materials [1]. Mobile ionic charge can also be used for the formation of junctions. Such junctions lead to diode characteristics and have enabled the assembly of transistors or light-emitting electrochemical cells [2].



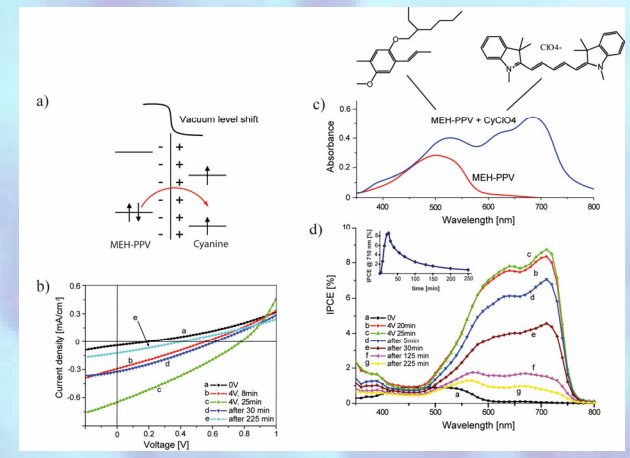
Cyanine dyes are charged semiconducting molecules that are accompanied by a counter anion. Therefore, cyanines have intrinsic built-in ionic and electronic charge conductivity. The counter anions are mobile and can be displaced across junctions. The build-up of ionic space charge creates electric fields and induces potential energy shifts similar to conventional p-n junctions. Thereby, ionic charge can be used to control the flow of electronic current [3,4].

Towards a cyanine / cyanine homojunction solar cell



(a) Synthesis scheme of a cyanine polymer that is soluble in protic solvents, but insoluble in aprotic solvents. (b) Fabrication scheme of a bilayer homojunction cyanine solar cell. Both cyanine layers are ~ 30 nm thick. (c) Applying a positive bias displaces the mobile counter anions into the cyanine polymer. (d) This builds up an electric field across the junction. (e) V_{oc} of the as-prepared solar cell is almost zero (t = 0); the cell is activated by applying a positive voltage (+4 V, 15 min); the system relaxes when the external voltage is turned off (relax, 80 min) or when a negative voltage is applied (-4 V, 10 min); the system is reversible and the junction can be re-established (+4V, 30 min).

A polymer / cyanine heterojunction solar cell



For as-prepared bilayer MEH-PPV / cyanine films, HOMO energies are close and charge transfer after photoexcitation of the cyanine is suppressed. (a) Displacing ClO_4^- (-) across the junction with an external voltage bias induces a potential energy shift and the device is "turned on". (b and d) V_{oc} and photocurrent response for different biasing and relaxation conditions. Effects are reproducible and reversible with a relaxation time of ~ 4 h.

References

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