known that there exist diblock or triblock copolymers having a conjugated sequence or diblock copolymers but not comprising any conjugated sequence. The document US 2008/0017244 is thus known but the block copolymers here act as transporter of charges (donor/receptor) and also as surfactant but do not solve the abovesaid first technical problem.

The document US2010/137518 is also known, which document provides for the addition, to the active layer, of a small amount of a diblock copolymer composed of an electron-donating block and of a second covalently grafted block with electron acceptors (fullerenes). This solution introduces improvements with regard to the efficiency but the synthesis of the additive is lengthy and complicated and no satisfactory result from the viewpoint of the stability over time and/or of the improvement in the efficiency without an annealing stage is obtained.

None of these existing solutions is very satisfactory regarding the control or the stabilization of the morphology of the mixing of electron-donating and electron-accepting materials.

Another major problem lies in the low effectiveness of the active layers of organic photovoltaic cells, which only very rarely exceed 5% efficiency. In point of fact, it is essential to increase this efficiency/effectiveness if it is desired to viably develop the photovoltaic applications.

Furthermore, there currently exists no additive capable of improving the efficiency or the stability of the organic solar cell and at the same time of eliminating the annealing stage.

Summary~~Brief description of the invention~~

The present disclosure~~invention~~ is intended to solve the problems of the organic photovoltaic cells of photovoltaic modules of the prior art by providing a composition for an active layer of an organic cell comprising a copolymer having linear architecture of a specific type.

It has been found, by the applicant, after various experiments and handling operations, that a specific structure could alone exhibit optimum results making it possible to improve the compatibilization of a mixture between an electron-donating

material and an electron-accepting material in an organic photovoltaic/solar cell, whether in terms of performance (energy efficiency) or in terms of stability (increased lifetime of the organic photovoltaic cell). Thus, the optimum structure of the active layer is obtained more easily and in a more lasting fashion (stabilized morphology) than for conventional processes (comprising one or more annealing stages). Specifically, it has also been shown that at least one of the examples of specific structure according to the invention makes it possible not only to improve the efficiency of the cell with respect to the reference but also to do it while dispensing with the annealing stage. This makes it possible to save time/lower the costs, in the manufacturing process, and to be able to prepare cells on flexible substrates without constraint due to the annealing temperature. The present invention thus relates to the improvement in each of the following properties/characteristics:

(a) effectiveness,

(b) manufacturing conditions,

(c) stability of organic photovoltaic cells by virtue of the action of a copolymer additive acting as compatibilizer and nanostructuring agent.

Thus, the present disclosure~~invention~~ relates to a composition of an active layer of an organic photovoltaic cell comprising:

- an electron-donating material consisting of a conjugated polymer;
- an electron-accepting material;

characterized in that the active layer comprises a copolymer having linear architecture comprising:

• from two to five blocks, including at least two blocks of different chemical nature;

• two consecutive blocks being of different chemical nature;

• each block exhibiting a molar mass of between 500 g/mol and 50 000 g/mol;

• none of said blocks being bonded by a covalent bond to the electron-accepting material.

In a first aspect, there is provided a composition of an active layer of an organic photovoltaic cell comprising: an electron-donating material consisting of a conjugated polymer; an electron-accepting material; characterized in that the active layer comprises a block copolymer having linear architecture selected from the group consisting of poly(3-hexylthiophene-*b*-isoprene), poly(3-hexylthiophene-*b*-styrene), poly(styrene-*b*-isoprene) or poly(3-hexylthiophene-*b*-(4-vinylpyridine)): wherein none of the blocks in said block copolymer is bonded by a covalent bond to the electron-accepting material.

The expression "having a linear structure" is understood to mean the fact that

the blocks of polymers forming the abovesaid copolymer stretch out, constituting a continuous chain of polymers exhibiting only two ends, in contrast to a three-dimensional structure, which exhibits at least three ends.

The expression "different chemical nature" is understood to mean the fact that the compounds or components do not belong to the same chemical family within the general group of thermoplastic polymers. By way of examples, a person skilled in the art distinguishes in particular the following chemical natures: polyamides, polyamideimides, saturated polyesters, polycarbonates, polyolefins (low- and high-density), polyestercarbonates, polyetherketones, polyestercarbonates, polyimides, polyketones, aromatic polyethers, and the like.

By virtue of the controlled structure of the copolymer having linear architecture according to the invention (number of blocks of polymers which are defined and low), one of the blocks will become located in the electron-donating material whereas the other polymer block of the copolymer will become located in the electron-accepting material (cf. figures 3 and 4). Thus, the copolymer according to the invention acts as a particularly advantageous surfactant (minimization of the difference in energy existing between the electron-donating material and the electron-accepting material) by decreasing the size of the domains in each of the two materials, which renders the entire active layer more stable and thus better in performance.

Other advantageous characteristics of the disclosure~~invention~~ are specified subsequently:

- particularly advantageously, the abovesaid copolymer comprises a single block consisting of a conjugated polymer;

- the conjugated polymer forming the electron-donating material and/or the abovesaid single block consisting of a conjugated polymer of the block copolymer consists of poly(3-hexylthiophene);

- advantageously, the electron-accepting material consists of at least one fullerene, preferably methyl [6,6]-phenyl-C_{61}-butanoate (MPCB);

- at least one of the blocks of the abovesaid copolymer consists of a polystyrene;

- at least one of the blocks of the abovesaid copolymer consists of a polyalkyl acrylate, preferably poly(n-butyl acrylate), or of a polyisoprene;

- at least one of the blocks of the abovesaid copolymer exhibits a Tg of less than 0°C, preferably of between -120°C and -50°C;

- the block copolymer consists of poly(3-hexylthiophene-*b*-isoprene), poly(3-hexylthiophene-*b*-styrene) or poly(styrene-*b*-isoprene).

In a second aspect, there is provided~~The invention relates to~~ the use of the composition as described above in the organic photovoltaic cells of a photovoltaic module.

In a third aspect, there is provided~~In addition, the invention also relates to~~ a photovoltaic module exhibiting at least one layer forming an encapsulant comprising a photovoltaic cell, consisting of a plurality of individual organic photovoltaic cells each comprising an active layer capable of generating electrical energy, and a layer forming a back sheet, the composition of said active layer is as described above.

Description of the appended figures

The description which will follow is given solely by way of illustration and without limitation with reference to the appended figures, in which:

- figure 1 illustrates the photovoltaic efficiency (PCE) as a function of the mass fraction of copolymer in the active layer for two different examples of linear block copolymers;

- figure 2 illustrates the standardized photovoltaic efficiency (standardized PCE) as a function of the illumination time;

- figure 3 is a diagrammatic representation of a solar cell, the active layer consisting of a mixture of an electron-donating material and of an electron-accepting material; this diagram represents a type of cell tested in the context of this invention; under no circumstances is the invention limited to this type of cell, which is just an embodiment, and the invention can be applied to cells of any other type, in particular cells with an inverted structure with respect to this,

- figure 4 is a diagrammatic representation of an interface between the two materials of the active layer which is stabilized by the block copolymer, this combination constituting the active layer according to the invention;