The synthesis for these types of polymers can vary from one to another. In this case, it can be a facile synthesis to a lengthy and tedious synthesis, leading to demand that a more efficient and facile synthesis be developed. In addition, fabrication techniques of different polymers are different from one another as well. In this regard, there is a demand for facile formation of alternative conducting polymer material that has a lower cost for storage and transportation of the polymer material. Further to that, there is also a demand to develop a more convenient method for the dispersion of the conducting polymer material and fabrication techniques of the same material onto substrate surfaces.

Accordingly, there is a need for such an alternative conducting polymer material that ameliorates one or more disadvantages mentioned above. There is a need to provide a method of forming such conductive polymer material that ameliorates one or more disadvantages mentioned above.

Summary

There is provided a method of forming a polythiophene:polysulfonate complex comprising the step of reacting a solution mixture of a thiophene and a polysulfonate salt in the presence of a catalyst and an oxidant under conditions to form the polythiophene:polysulfonate complex.

According to a first aspect, there is provided a method of forming a polythiophene:polysulfonate complex comprising the step of: a) reacting a solution mixture of a thiophene and a polysulfonate salt in the presence of a catalyst and an oxidant, wherein said oxidant is an ammonium salt, in an inert atmosphere, under conditions to form said polythiophene:polysulfonate complex; b) separating the formed polythiophene:polysulfonate complex from the reaction; and c) washing said polythiophene:polysulfonate complex.

Advantageously, the above method may result in the production of solid polythiophene:polysulfonate complex that can be easily separated from the reaction mixture through standard purification methods such as filtering or centrifuging.

There is provided a method of forming a film of a polythiophene:polysulfonate complex on a substrate surface comprising the steps of (a) coating the substrate surface with a dispersion of the polythiophene:polysulfonate complex; and (b) drying the coated polythiophene:polysulfonate complex to form the film.

According to a second aspect, there is provided a method of forming a film of a polythiophene:polysulfonate complex on a substrate surface comprising the steps of: (a) coating the substrate surface with a dispersion of the polythiophene:polysulfonate complex; (b) adding an additive selected from the group consisting of ethylene glycol and dimethyl sulfoxide (DMSO), to the dispersion; (c) dropping an alcohol onto the coated polythiophene:polysulfonate complex; and (d) drying the coated polythiophene:polysulfonate complex to form the film.

Advantageously, the polythiophene:polysulfonate complex film may be conductive across a wide range from 10^{-3} to 400 S/cm.

There is provided a polythiophene:polysulfonate complex made according to a method as defined herein.

According to a third aspect, there is provided a polythiophene:polysulfonate complex in the form of a solid made according to a method as defined herein.

According to a fourth aspect, there is provided a film of a polythiophene:polysulfonate complex made according to a method as defined herein.

Definitions

The following words and terms used herein shall have the meaning indicated:

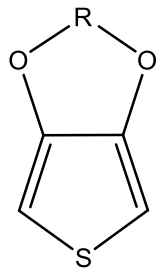
The term “conductive polymer or semi-conductive polymer” is to be interpreted broadly to include a network of organic polymers that conduct electricity. Such compounds may have metallic conductivity or can be semi-conductors. The biggest advantage of conductive polymers is their processability, mainly by dispersion. Conductive polymers are generally not thermoplastics, i.e., they are not thermoformable but like insulating polymers, they are organic materials. They can offer high electrical conductivity and optical properties but do not show similar mechanical properties to other commercially available polymers. The

Claims

1. A method of forming a polythiophene:polysulfonate complex comprising the step of:

a) reacting a solution mixture of a thiophene and a polysulfonate salt in the presence of a catalyst and an oxidant, wherein said oxidant is an ammonium salt, in an inert atmosphere, under conditions to form said polythiophene:polysulfonate complex;
b) separating the formed polythiophene:polysulfonate complex from the reaction; and
c) washing said polythiophene:polysulfonate complex.

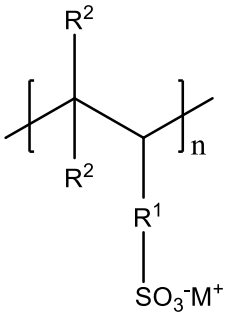
2. The method according to claim 1, comprising the step of providing said thiophene having a general formula (I)



(I)

wherein
R is a C_{1-6}-alkylene radical optionally substituted with one or more of C_{1-6}-alkyl, C_{2-6}-alkenyl, C_{3-6}-cycloalkyl or hydroxyl.

3. The method according to claim 1 or 2, comprising the step of providing said polysulfonate salt having a general formula (II)



(II)

wherein
R^1 is selected from the group consisting of a bond, C_{1-6}-alkyl, C_{2-6}-alkenyl, C_{3-6}-cycloalkyl and aryl, wherein said C_{1-6}-alkyl, C_{2-6}-alkenyl, C_{3-6}-cycloalkyl or aryl is optionally substituted with one or more of C_{1-6}-alkyl, C_{2-6}-alkenyl, C_{3-6}-cycloalkyl, aryl or hydroxyl;
R^2 is independently selected from the group consisting of C_{1-6}-alkyl, C_{2-6}-alkenyl, C_{3-6}-cycloalkyl and hydroxyl;
M^+ is a cation selected from an alkali metal cation or an ammonium ion; and
n is in the range of 2 to 600.

4. The method according to claim 1 or 2, wherein said polysulfonate salt is selected from the group consisting of poly(sodium-4-styrenesulfonate), poly(lithium-4-

styrenesulfonate), poly(potassium-4-styrenesulfonate) and [poly(styrenesulfonate), ammonium salt].

5. The method according to any one of the preceding claims, comprising the step of selecting said thiophene and said polysulfonate salt at a molar ratio of 1:1 to 1:3.

6. The method according to any one of the preceding claims, wherein said catalyst is a transition metal salt.

7. The method according to any one of the preceding claims, wherein said reacting step is undertaken in a temperature in the range of 20 °C to 30 °C.

8. A polythiophene:polysulfonate complex in the form of a solid made according to the method of any one of the preceding claims.

9. A method of forming a film of a polythiophene:polysulfonate complex on a substrate surface comprising the steps of:

(a) coating said substrate surface with a dispersion of said polythiophene:polysulfonate complex;

(b) adding an additive selected from the group consisting of ethylene glycol and dimethyl sulfoxide (DMSO), to said dispersion;

(c) dropping an alcohol onto said coated polythiophene:polysulfonate complex; and

(d) drying said coated polythiophene:polysulfonate complex to form said film.

10. The method according to claim 9, further comprising repeating the steps as defined in claim 9 to form a multi-film layer on said substrate surface.

11. A film of a polythiophene:polysulfonate complex made according to the method of claim 9 or 10.