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Investigation of an n-type conducting polymer for potential use in all-polymer thermoelectric generators

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Thermoelectric generators are a promising approach in renewable energies, as they are able to convert waste heat into electricity. Possible applications are large scale applications like recovering the waste heat of a car engine as electricity as well as niche applications like using the heat emitted by human skin to drive a watch.[1]

In practice, a thermoelectric generator traditionally consists of a p- and an n-type semiconductor electrically connected as shown in Fig. 1.
In order to put the device into operation, a temperature gradient is applied along the legs. As a consequence, charge carriers, i.e., holes in the p-type and electrons in the n-type leg, respectively, diffuse from the hot to the cold side. This diffusion current causes a build-up of charge at the cold end that can be extracted by connecting a load. All in all, a thermoelectric generator is able to convert a temperature gradient into electric energy.

To build high efficiency thermoelectric devices, suitable thermoelectric materials are needed. Unfortunately, state-of-the-art thermoelectric materials have the drawback of using toxic or less abundant constituents, making it necessary to look for alternatives. One promising approach to overcome such challenges is to use conjugated polymers. They have the encouraging ability of easy and various types of scalable solvent processes like roll-to-roll printing. Although they are still less efficient than their inorganic counterparts, their potential flexibility and eco-friendliness make them a valuable alternative.

Various, especially p-type, conducting polymers have been investigated as thermoelectric materials. A very promising candidate among them is the hole-conducting PEDOT. Unfortunately, n-type polymers have rather been neglected which might stem from their low stability towards oxygen and moisture. Nonetheless, both types are needed for a thermoelectric device as explained before. Therefore, we also focus on the thermoelectric properties of the n-type polymer P(NDI2OD-T2). Its successful application to transistors [3] and solar cells [4] encourages an auspicious attempt in building an all-polymer thermoelectric generator. Both polymers which are investigated in our group are shown in Fig. 1 next to the leg where they are of potential use.

The main focus of this work is to enhance the so-called power factor where is the electrical conductivity and is the Seebeck coefficient. As already indicated by its name, the larger the power factor the larger the power output and subsequently the efficiency of the device.
Therefore, we successfully doped P(NDI2OD-T2) with an organic small molecule which can even be seen in a color change depicted in Fig. 2. The experiment resulted in a maximum power factor of .

References
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