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Thermoelectric Materials: Promising Energy
Energy is one of the most coveted resources in society today. Most households use an excessive amount of energy to power their technological devices. Our hospitals and labs also use energy to maintain the health and well-being of people around the globe. These energy uses make it crucial that we reduce our impact on the world around us, while obtaining the energy needed to sustain life. Renewable energy helps cities to reduce their environmental impact, while improving the quality of life for citizens. One growing method of obtaining renewable energies called thermoelectric materials has shown some promising signs. This process uses the differences in temperature from the sun, to humans, and even automobiles to change heat energy into usable electric energy. Increasing the number of green buildings utilizing thermoelectric materials, and other renewable energies improves the environment in which we live and creates a more sustainable system for all posterity.

The conversion of energy happens via several different processes. Improvements in energy production have led to the use of thermoelectric materials. “A thermoelectric (TE) device can directly convert heat emanating from the Sun, radioisotopes, automobiles, industrial sectors, or even the human body to electricity,” (Tritt, He, 2017). The abundance of ambient energy leads to a more available source of energy. By using materials from the surrounding area, we can reduce the cost and improve the efficiency of energy production. The use of this technology has increased over the past few years and has led to a more sustainable system for cities. “… naturally occurring temperature variations also can provide a means by which energy can be scavenged from the environment with high temperature,” (Yildiz, 2009). By using the temperature differences, scientists have been able to convert heat energy into usable electrical energy.
The use of a BiCuSeO thermoelectric system has led to the development of a new technology. By using the differing characteristics of elements, scientists have been able to maximize the efficiency and sustainability of this process. One major use of this BiCuSeO system has been to take advantage of its behavior to cause an increase in performance. Scientists Xiaoxuan Zhang, Cheng Chang, Yiming Zhou, and Li-Dong Zhao of the Beihang University have compared the several different characteristics and methods used to improve the process of thermoelectric energy generation. Similarly, an article by Terry M. Tritt, and Jian He states, “We also expect increasing efforts to develop high-performance materials out of nontoxic and earth-abundant elements,” (Tritt, He, 2017). This shows the scientific community that by using nontoxic and abundant elements, the production of energy can be made clean and cost efficient. An article from last May states that, “Researchers trying to bring them (Thermoelectric Systems) into wider use by making more efficient, less expensive materials have been tantalized by metallic compounds such as copper selenide,” (Patel, 2019). This illustrates to readers that new research shows many different combinations of common earth elements demonstrate great promise and cost efficiency of thermoelectric energy generation.

To fully understand the improvements that are achieved using thermoelectric materials systems, scientists must compare the characteristics, properties, and the effectiveness of each system to help to draw conclusions that may lead to a breakthrough. Scientists use figures of merit to determine the strengths and weaknesses of different methods and materials. “The figure of merit, ZT, is the primary measure of material performance. Enhancing the ZT requires optimizing the adversely interdependent electrical resistivity, Seebeck coefficient, and thermal conductivity, as a group,” (Tritt, He, 2017). Optimizing each of these properties benefits the
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system and allows scientists to produce a large amount of energy while not creating large amounts of pollutants.

Comparatively, by, “... enhancing thermoelectric properties through doping and compositing, developing less time-consuming methods, … exploring the origins of low thermal conductivity, …,” help us, “to enhance thermoelectric performance of BiCuSeO systems,” (Zhang, 2017). More specifically, “...heavy doping can improve the carrier concentration significantly. On the other hand, the excessive dopants decrease the carrier mobility… Therefore, the methods that enlarge the carrier mobility and maintain the carrier concentration can be expected to enhance the electrical transport properties,” (Zhang, 2017). This quote explains how doping can improve the carrier concentration; however, it may limit the mobility of the carrier. Optimizing these two properties will help to increase the yield of energy through thermoelectric materials and to improve its efficiency. There are many more factors that need to be optimized along with these properties. Only when all are optimized, will the systems be the best option that they can be.

By using similar characteristics, and properties of several different elements, scientists have formulated various element combinations that help to improve the production of electrical energy from heat energy. One study states that, “Due to its layered structure, BiCuSeO shows anisotropic transport behaviors along in-plane and out-plane directions for both electrical and thermal conductivity. The electrical and the thermal transport properties along the in-plane direction outperform those along the out-plane direction,” (Zhang, 2017). Scientists use this property to determine the behaviors and benefits of using this combination of elements. Similarly, properties are used to determine that, “Electricity also can drive a TE device to work as a solid-state heat pump for distributed spot-size refrigeration. TE devices are free of moving
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parts and feasible for miniaturization, run quietly, and do not emit greenhouse gasses. The full potential of TE devices may be unleashed by working in tandem with other energy-conversion technologies,” (Tritt, He, 2017). This quote explains that by using thermoelectric devices, convenience, and practical uses can be made to improve everyday devices. This quote from Tritt and He also explains that during production, the energy does not emit greenhouse gases, making this an environmentally friendly process.

Over the past few years, many new methods of thermoelectric energy generation have been examined. One of which states, “In this material, ions flow fast and free, just as they do in liquids. This becomes a liability in a thermoelectric module because the free-flowing ions deposit on the electrode and ruin the device after just a few hours,” (Patel, 2019). This shows that many of the experiments that are being conducted are based on trial and error. With a wider scope of research, the promise of reliable renewable energy is becoming much greater,

As a society, we must create a stable, and sustainable system to help counter our impact on the environment and thermoelectric energy generation has shown to maximize these results. The rate of ozone depletion is alarming and must be slowed. Renewable energies help to reduce this impact, but not all options are equal. The power density of each form of energy helps scientists to determine the most effective, and practical way to solve the energy crisis. “The renewable energy landscape will be reshaped if the current trend in thermoelectric materials research is sustained into the foreseeable future,” (Tritt, He, 2017). As elucidated in this quote, although many forms of energy generation exist very few have the research and promise greater or equal to that of thermoelectric materials.

The current events surrounding the COVID-19 pandemic have shown that the need for energy has become crucial for all modern life. From working at home, to hospital workers,
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electrical energy drives our everyday lives through our devices. Although gas powered car emissions are down, the pollution created by energy generation is still high. By investing time and research in Thermoelectric Materials, scientists can reduce the amount of greenhouse gas emissions, while creating a precious commodity. Thermoelectric Materials may be the solution that many have been searching for to produce affordable clean energy.
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