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THERMOELECTRIC PROPERTIES OF COMMERCIAL ZINC OXIDE AND ALUMINIUM DOPED ZINC OXIDE

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Most of the available machinery at operation generates excess heat, and hence a significant amount (around 66%) of the input fuel energy is wasted as heat. Therefore, waste heat recovery technologies such as thermoelectric generators are important to increase their overall energy efficiency. Thermoelectric generators are considered reliable technology that directly converts thermal energy into electrical energy. These devices are generally fabricated using alternative arrangements of suitable p-type and n-type semiconductors electrically in series and thermally in parallel. Zinc oxide (ZnO) is an inorganic n-type semiconductor that has received a great deal of attention to realise a high-temperature thermoelectric generator. In the present study, thermoelectric properties of pellets prepared using commercial ZnO and aluminium doped ZnO were observed at relatively lower temperatures. For this purpose, Al-doped ZnO was synthesised using a new chemical method. The successful synthesis of ZnO hexagonal wurtzite phase and doping were confirmed using powder X-ray diffraction pattern (JCPDF-01-079-0205). Pellets of synthesised Al-doped ZnO and commercially available ZnO powder were prepared at an applied uniaxial (non-isostatic) pressure of 295 MPa, which was lower than the pressures used in the literature, and their individual thermoelectric properties were observed at lower temperatures. The findings of this study are the synthesis method, low-pressure palletisation using wet ZnO and the generation of relatively high potential difference at low temperatures. The electrical conductivities of commercial ZnO and Al-doped ZnO were 31.3 S m^{-1} and 35.6 S m^{-1} (at 373 K). The thermal conductivities of these materials were 2.38 W m^{-1} K^{-1} and 1.40 W m^{-1} K^{-1} (at 373 K), respectively. Both materials showed negative Seebeck coefficient values of -165 µV K^{-1} and -225 µV K^{-1}, respectively, indicating the n-type semi-conductive behaviour. The dimensionless parameter figure of merit (ZT) characterises a material's ability to convert thermal energy into electricity. The ZT for ZnO and Al-doped ZnO were 1.34×10^{-4} and 4.80×10^{-4} (at 373 K), respectively. Commercial ZnO and Al-doped ZnO generated a potential difference of 14.9 mV and 19.9 mV, respectively, at a 90 K temperature difference across the hot and cold ends.

Keywords: Renewable energy, Seebeck effect, Semiconductors, Thermoelectricity