INVESTIGATING THE ELECTROCALORIC EFFECT IN PVDF-BASED POLYMER

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Résumé

The demand for cooling is growing at an alarming rate and currently constitutes a significant portion of the global electricity consumption. However, the predominant method of meeting this demand involves the use of vapor-compression refrigerators, which unfortunately rely on gaseous refrigerants that are largely detrimental to the environment (1-3). An alternative solution based on solid-state refrigeration systems that utilize electrocaloric (EC) materials has emerged as a promising approach. In particular, the lead-free P(VDF-TrFE-CFE) terpolymer (terPo) ferroelectric has garnered significant attention as a potential refrigerant due to its robust electrocaloric response and has already been incorporated into some recent cooling devices (4, 5). The EC Effect refers to the change in temperature of a material in response to an applied electric field.

Since the EC effect was discovered, various direct and indirect measurement methods have been employed. For accurate measurement of the complex thermal response of ferroelectric relaxor, a direct temperature measurement is necessary. However, direct temperature measurement is challenging for thin films, which are typically less than 30 um thick. To overcome this challenge, different methods have been proposed, including optical methods and the use of thermistors.

Non-contact methods, such as optical methods, are attractive as they do not affect the sample being measured. However, the use of conductive electrodes for such methods results in poor emissivity, making intensity-based measurement challenging (6). Additionally, emissivity values depend on surface conditions, such as surface roughness, thickness, periodic surface microstructures, oxide layers, physical or chemical contamination, and distance between materials and the sensor (7). As a result, emissivity values reported in literature are often inaccurate and differ from each other. To address this issue, using a coating with a known emissivity is an interesting solution, but it adds an additional thermal load on the film, which must be perfectly known.

In this work, a measurement technique based on a flexible thermistor has been developed

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to measure the delta T of electrocaloric films. a figure of merit that measures the cooling efficiency has also been introduced, to demonstrate its effectiveness in evaluating a material's cooling performance under real-world conditions. The study includes an analysis of the material's performance at working frequencies and applied fields, which are in line with typical refrigeration cycles. The results are then compared to those obtained under laboratory testing conditions, where a unipolar sinusoidal waveform is used. The findings indicate that the caloric response and losses are significantly influenced by the voltage profile and frequency. The study goes on to estimate the maximum efficiency of terPo using these measurements and compares it to the reported cooling efficiencies of actual devices. The results show good agreement with data from the literature.