Energy Harvesting From Pavement via PVDF: Hybrid Piezo-Pyroelectric Effects

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Background
In the U.S., there are over 4 million miles (6 million km) of roadways and more than 250 million registered vehicles. The energy lost in the pavement system due to traffic-induced vibration and deformation is enormous. If effectively harvested, such energy can serve as an alternative sustainable energy source that can be easily integrated to the transportation system.

Objective
In this study, the electrical response of PVDF under coupled mechanical and thermal stimulations are studied. It is well known that most piezoelectric materials are also pyroelectric materials, which convert temperature change into electricity. However, the potential of PVDF as a hybrid piezo-pyroelectric energy harvester has been seldom studied. This study aims to
1) uncover the coupling between piezoelectric and pyroelectric effects of PVDF through laboratory experiments.
2) Estimate the energy output of PVDF harvester under real life traffic and temperature conditions

Preliminary Results

Model of piezoelectric effect induced charge:

\[ Q_p = \rho \Delta T A_{PVDF} \]

where \( Q_p \) is piezoelectric effect induced charge, \( \rho \) is piezoelectric coefficient, \( \Delta T \) is the temperature change and \( A_{PVDF} \) is the surface area of the harvester.

Model of pyroelectric effect induced charge:

\[ Q_T = \sigma_3 \Delta \rho \]

where \( Q_T \) is pyroelectric induced charge, \( \sigma_3 \) is pyroelectric coefficient, \( \Delta \) is the temperature change and \( \rho \) is the surface area

Model of total charges induced by the hybrid piezo-pyroelectric effect in a day:

\[ Q_{day} = Q_p + Q_T + Q_{day} = \rho A_{PVDF} \sum_{day} \Delta T | + 4 N d_{33} \sigma_3 A_{cont} \]

where N is traffic volume per day.

Case Study Results

Future Research
- Develop novel new materials, such as combining PVDF with nanoparticles

Reference