PROMISING ALTERNATIVE TECHNOLOGY FOR COMPRESSORS IN COOLING CYCLES

Engineers at AU research membranes for potentially more durable and more efficient compressors for cooling cycles for e.g. refrigerators. To this end researchers create specialized equipment for direct measurements of the electrokinetic energy conversion efficiency.

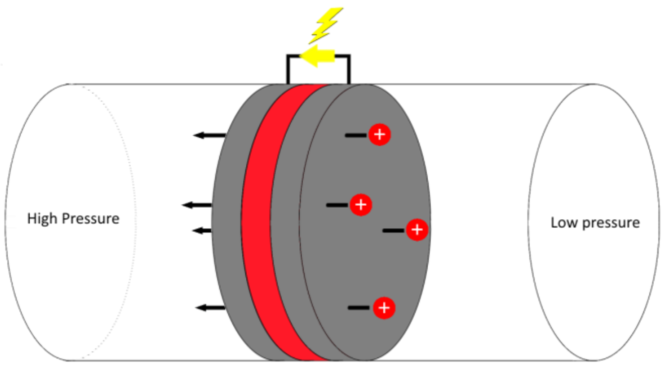
Project focus: Energy conversion
Conversion of energy from one form into another plays a significant role in many industrial applications today. In batteries electrical energy is converted to electrochemical energy while charging and in turn converted back to electric energy while discharging. Compressors turn electric energy into kinetic energy by raising the pressure of some gas. Air conditioners, refrigerators or other cooling devices apply cooling cycles which is a whole bunch of energy conversions at the same time. One of which is the conversion of the compressor.

Compressors used today for different appliances of cooling cycles convert energy inefficiently and have moving parts making them become more inefficient over time. The moving parts also restrict the size of such compressors, as there is a certain limit to how small you can make them.

The main objective of this research project is to develop a more durable and efficient compressor. In order to achieve this, the focus lies on applying membranes for the electrical to kinetic energy conversion. These membranes have pores in the nanometer range and are charged such that only selected ions are allowed to pass through. This selectivity is taken advantage of during electrokinetic energy conversion operations.

Electrokinetic energy conversion

The pore walls of the membranes used are negatively charged. This ensures that only positive ions (cations) are allowed to pass through the membrane and thereby blocking negative ions (anions). So imagine a membrane sandwiched in between two electrodes and a solution of some positively charged ion in for instance water is present. Now an electrical current is introduced across the membrane resulting in the cations being dragged through the membrane. This happens because of the electrode reactions taking place in both electrodes. The reactions in each electrode are opposite such that a negative and positive charge is joined on one side and separated on the other, driving the whole process.



As the positively charged ions move through the membrane they drag solvent molecules with them. In the case of the solution being in the vapour phase this means an increase of gas molecules on one side of the membrane which in turn leads to an increase in pressure. The result is a conversion of electrical energy into kinetic energy in the form of a pressure gradient across the membrane. As the process is reversible it is possible to apply a pressure gradient instead of the electrical current and then get electrical energy out of the system: Simply imagine all the arrows of the figure above turned around. Now the cations are being pushed through the membrane by the pressure gradient dragging electrons in the outer circuit with them.

Membrane characterization

When talking about energy conversion there is an important factor to consider: conversion efficiency. How much of the energy input is gathered as an output. A second objective of this research project includes characterisation of the membranes used for the electrokinetic energy conversion. A lot of parameters play an important part in how well the membrane preforms. Among them are:

- **Ion conductivity**
  How well does the membranes transport ions when introduced to an electrical current?
- **Hydraulic permeability**
  How well does the membranes transport mass when under a pressure difference?
- **Streaming potential**
  What is the achievable electrical potential across the membrane when under a pressure difference?

Measuring and combining these three parameters are how researchers up till now have been determining the maximum conversion efficiency. But unfortunately this has not been a measure for the actual conversion efficiency. Specialized equipment have been constructed in order to measure the exact energy input and output by monitoring pressures, mass transport and electrical potential and current. This enables a direct measurement of the conversion efficiency.

Technological potential of electrokinetic energy conversion

Today compressors in for instance refrigerators are not very efficient, meaning the percentage of electrical energy converted into kinetic energy is low. Calculations based on theory show that applying electrokinetic energy conversion holds potential for exceeding existing conversion efficiencies. This alone is a promising aspect, but also the possibility that an electrokinetic compressor might be created on such a small scale, that conventional compressors will never be able to go to, is a valuable goal to seek for. Lastly the lack of moving parts in the electrokinetic compressor could ensure longer durability and thereby reduced costs.
As the interest for this field has only re-emerged in recent years the research coverage is sparse. This is why there is a need of creating specialized equipment to analyse different membranes. In turn yet another challenge lies in synthesizing and casting the optimum membranes for the purpose. These are some of the gabs researchers are trying to fill in order to develop real-life applications.

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