

## Homework 11 Solar Power for Africa Due Monday November 6, 2023

Z. F. Li and K. Sumathy published a paper on a methanol/activated carbon absorption refrigerator (*Int. J. Energy Res.* **23** 517-527 (1999)). They include the Clapeyron diagram shown below (x axis should be  $1/T$ ).

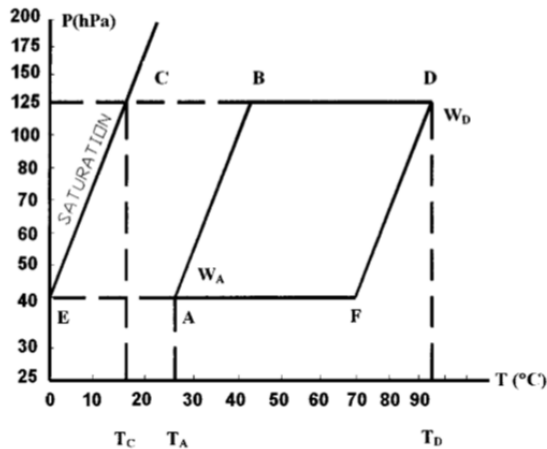
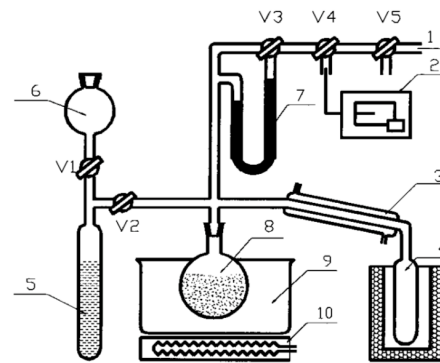


Figure 5. Clapeyron diagram ( $\ln P$  vs.  $-1/T$ ) of ideal solid-adsorption cycle



1-connect vacuum pump, 2-McLeod-gauge, 3-cooling water (condenser), 4-evaporator, 5-methanol reservoir, 6-methanol inlet bottle, 7-U-gauge(mmHg), 8-activated carbon bottle, 9-oil tank, 10-electric stove

- a) Li and Sumathy arrive at a coefficient of performance (COP) of about 0.5.  $T_E$  was  $-10^\circ\text{C}$  and  $T_D$  was  $110^\circ\text{C}$  in Figure 5. For these temperatures (not those shown in figure 5) what is the COP for a Carnot cycle under these conditions.
- b) Why does the solar absorption refrigerator have a lower COP than a Carnot cycle? List some issues with the device that could explain the reduction in performance. Some are listed in the paper.
- c) The refrigerator produces 5 kg of ice per day for 17 kg of activated carbon and a  $1\text{ m}^2$  solar collector with  $18\text{ MJ/m}^2$  solar irradiance per day. Compare this with a PV solar panel whose efficiency is about 15%. The heat of fusion for ice is  $334\text{ J/g}$  and a commercial freezer has a COP of about 0.85 for this temperature range.
- d) Most of the design studies that are published for absorption refrigerators anticipate home use of the device, while most existing applications are for moderate- to small-scale communal or commercial applications such as at a dairy or a winery. Explain why you think the applications are not in the areas of intended use by the researchers. What does this say about researchers?
- e) Patrick Sherwin from GoSun introduced a [battery/photovoltaic powered cooler chest](#). Compare the GoSun products with the [Crosley Icy Ball](#). A few years ago, I mentioned to Patrick that absorption refrigeration could also be used as a solar refrigerator, however, he didn't pursue that path. Compare the two devices, explain how the Icy Ball works and give your opinion on which technology is best.