Estimating of dew yield from the calcite dew condenser

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Abstract

In this study, we focus on dew harvesting as a new-researched area. This paper presents an energy balance modelling approach to predict the nightly water yield from meteorological data in semi-arid region (Mirleft, Southern Morocco). The proposed approach provides a comprehensive report on a thin film of calcite mineral (CaCO3) that can be used as a selective shield allowing dew condensation during the night. The increased cooling of the exposed shield (condenser) was exploited using high IR emissivity of the calcite in the atmospheric window (8-13 microns).

Model for the radiative condensation effect

Dew harvesting can be determinate from meteorological data according to the approach presented by Nikolayev et al., Jacobs et al. and H. Vuollekoskin et al. The estimation of the dew yield requires solving the heat equation based on an equilibrium equation between sensitive and latent heat fluxes[1]. The heat energy balance is given by the following equation:

$$\left(\frac{dT_c}{dt}\right)(MC_c + m_w C_w) = q_{IR} + q_{cd} + q_{conv} + q_{cond}$$

Here Tc, M and Cc are the dew condenser's temperature, mass and specific heat capacity, respectively. Cw and Mw are the specific heat capacity and mass of water, representing the cumulative mass of dew water that has condensed onto the collector sheet.

Calcite description and characterization

In Calcite or calcspar is the mineral name of the low-pressure, hexagonal form of calcium carbonate, CaCO3. Calcite is the principal constituent of limestone, marble and chalk. Calcium carbonate nucleates in three crystalline forms: aragonite, calcite and vaterite, with orthorhombic, rhombohedral and hexagonal structure, respectively. Calcite is the most stable phase thermodynamically at surface conditions, then arrogant or varterite [2]. Calcite is one of the main components of the scaling which arises in various drainage situations in the chemical industry, in circulating water for heating and cooling in living environments and in is also used as an additive in various industrial fields, e.g., building materials, food, paper, plastics[3].

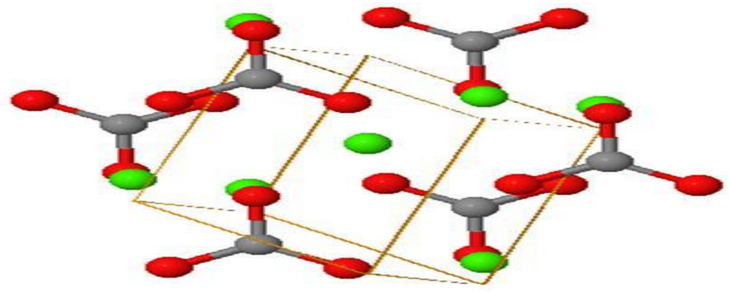

Fig.1 Rombohedral unit cell of calcite (m space group), containing six units and seven Ca++ ions

Results : vibration modes

we have presented the different vibration modes stretching of calcite calculated by PM3 semi-empirical method. The calculated frequencies are in general very close to the experimental ones. Most of the calcite vibrational IR and Raman frequencies is related to specific vibrational modes of the carbonate anion (CO_3^-).

Frequency IR(cm^{-1})	Frequency Raman(cm^{-1})	Symmetry type	Assignments
709	----	A_{2u}	$bending\ in\ plan\ \delta_{CO3}$
711	----	E_u	$bending\ in\ plan\ \delta_{CO3}$
874	----	A_{1u}	$bending\ out\ of\ plan\ \delta'(CO3)$
882	----	A_{2g}	$bending\ out\ of\ plan\ \delta'(CO3)$
-----	1083	A_{1u}	$stretching\ symétric\ \nu_s\ (CO3)$
-----	1088	A_{1g}	$stretching\ symétric\ \nu_s\ (CO3)$
-----	1400	E_u	$stretching\ antisymétric\ \nu_{as}\ (CO3)$
-----	1432	E_g	$stretching\ antisymétric\ \nu_{as}\ (CO3)$

Tab 1: Vibrational IR and Raman frequencies of calcite, symmetry types and possible assignments

Results : dew yield

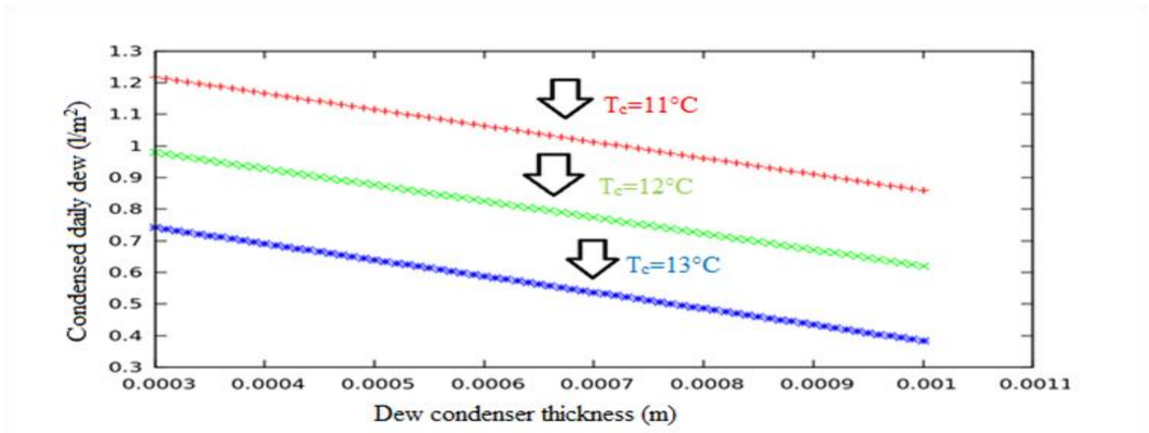

Fig 1 : The net effect of condenser thickness on estimated dew yield at three different values of condenser temperature Tc.

Figure 4 presents the sensitivity of the estimated dew yield to the dew condenser thickness as well as to the different values of dew condenser temperature.

Conclusion

Our model based on solving the heat and mass balance equations exhibits gives a general linear relationship between dew yield and condenser temperature or condenser thicknesses.

References

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