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The role of nanoclay addition on the elastocaloric performance of Natural Rubber

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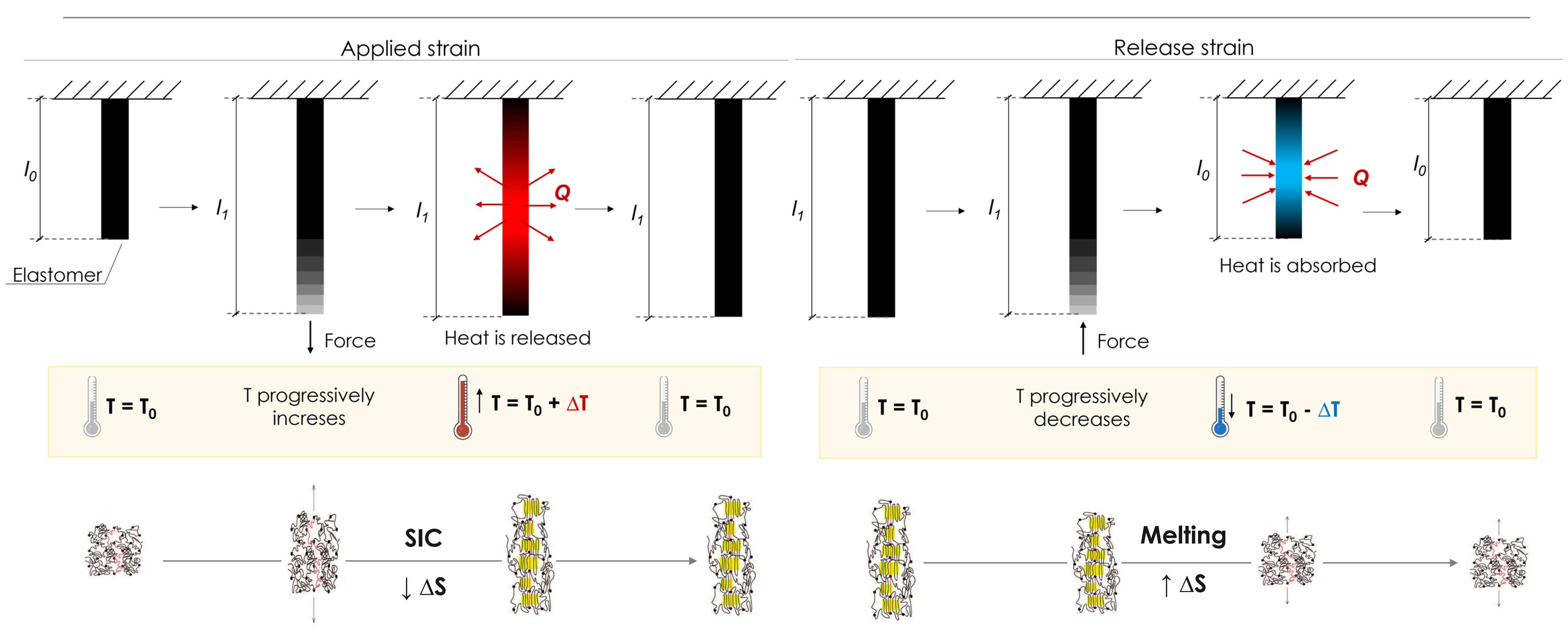
INTRODUCTION

WILL THE ELASTOCALORIC EFFECT OF NATURAL RUBBER CHANGE THE FUTURE OF AIR CONDITIONERS?

- Strain induced crystallization (**SIC**) is the major contributor to the elastocaloric effect of NR.
- Addition of nanoclays has demonstrated to enhance SIC of NR.

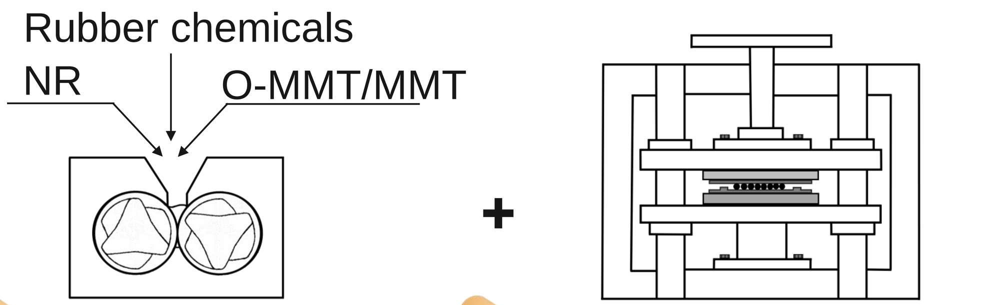
ELASTOCALORIC EFFECT



EXPERIMENTAL

SAMPLE PREPARATION

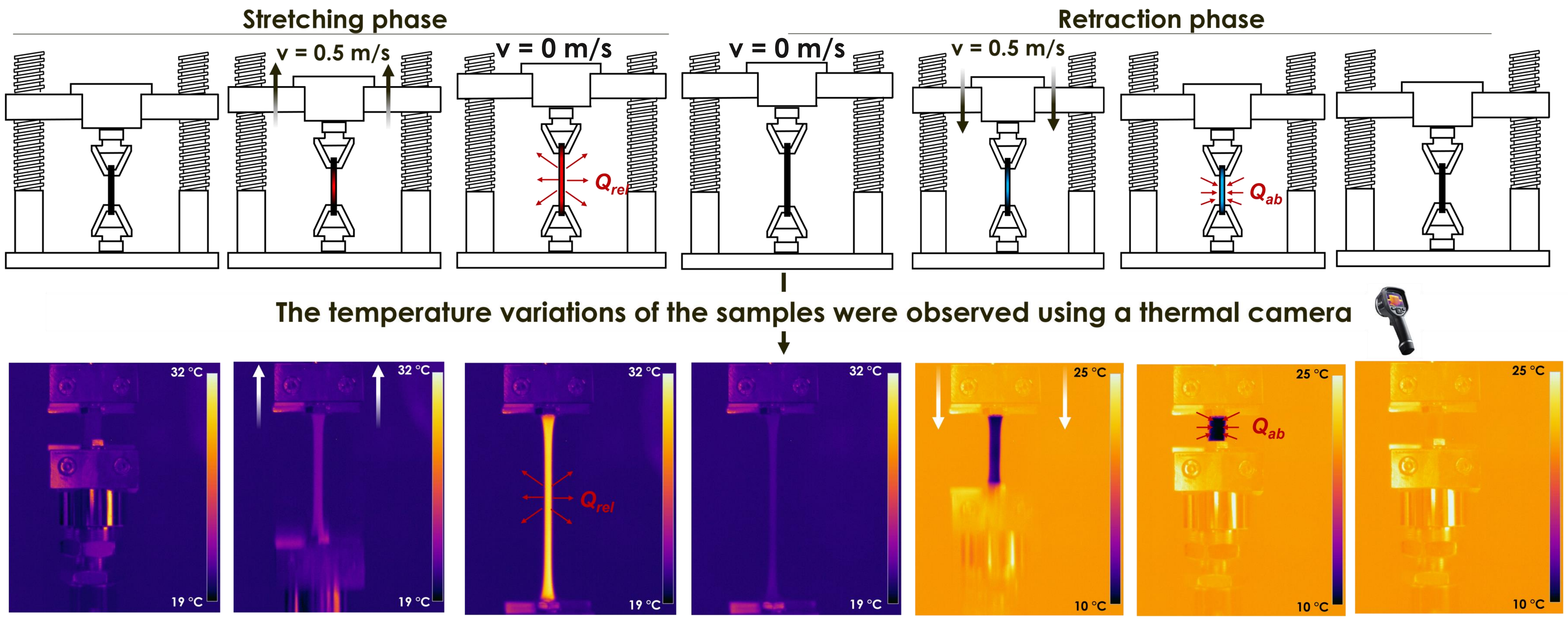
- Natural Rubber TSR 10, SMR.
- Cloisite® 20 A, d_{001} = 2.70 nm (O-MMT).
- Cloisite® Na+, d_{001} = 1.17 nm (MMT).



NR_1MMT 1 phr MMT	**NR_1O-MMT** 1 phr O-MMT
NR_3MMT 3 phr MMT	**NR_3O-MMT** 3 phr O-MMT
NR_5MMT 5 phr MMT	**NR_5O-MMT** 5 phr O-MMT

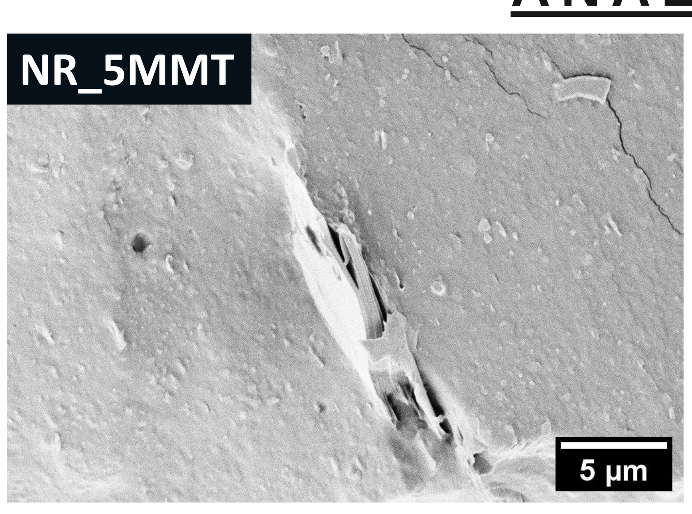
EVALUATION OF THE ELASTOCALORIC EFFECT

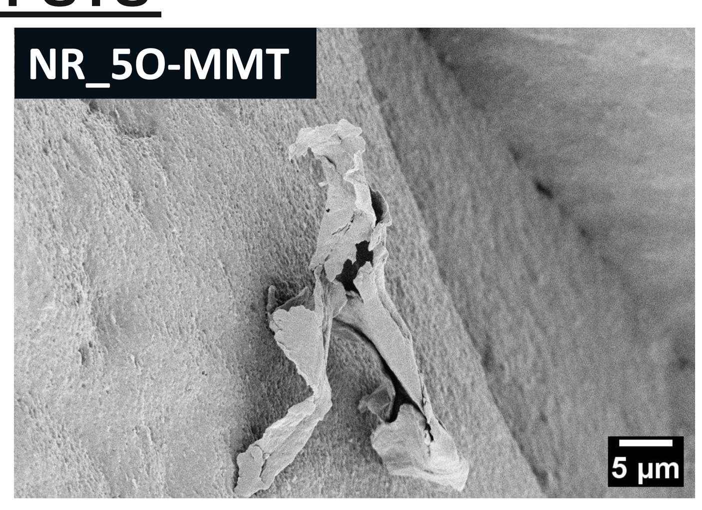
Set up: high-speed tensile testing machine (STEP Lab S.r.l, Resana, Italy).
Samples: 25x15x1 mm³.



RESULTS&DISCUSSION

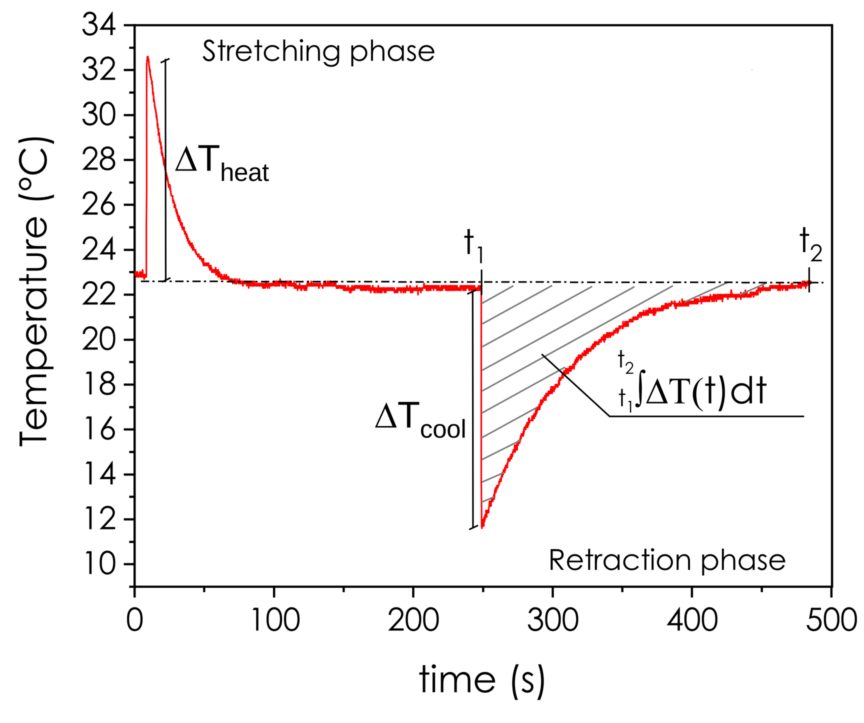
STRUCTURAL AND MORPHOLOGICAL ANALYSIS





- Good degree of **intercalation/exfoliation of the organo-modified nanoclays** within the NR matrix.
- **Natural MMT** exhibits a strongly **aggregated morphology**.

ELASTOCALORIC EFFECT:CALCULATIONS

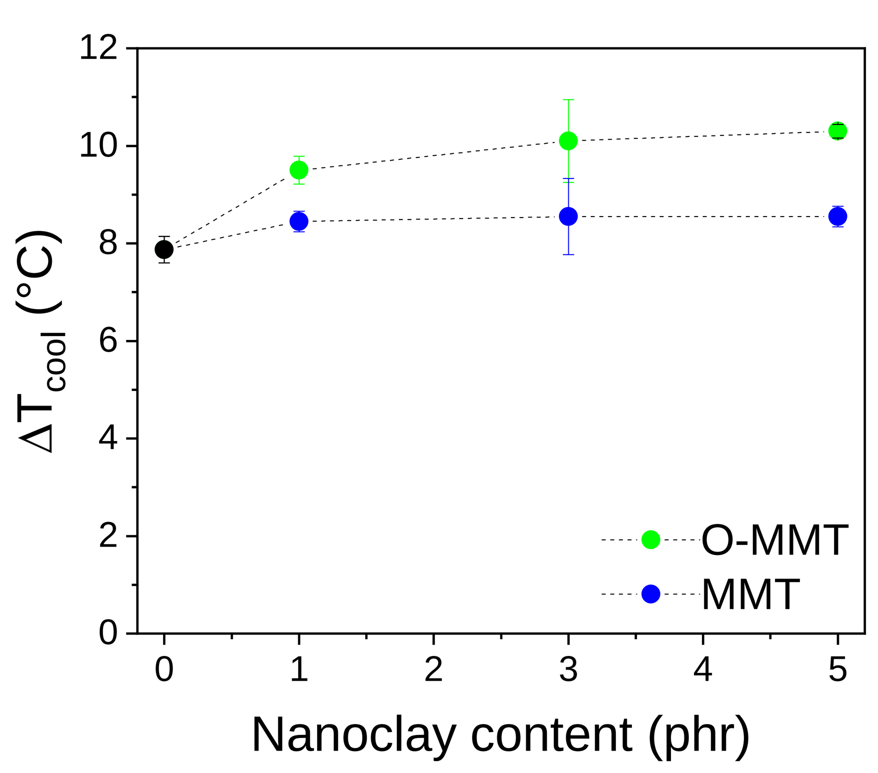


- Deformation level: **400%**
- ΔT_{cool}
- Heat absorbed per unit volume: $Q_{ab} = (h \cdot A \cdot \int_{t1}^{t2} \Delta T(t)dt\ )/V$
- Coefficient of performance: **COP** = Q_{ab}/(Work of def.)

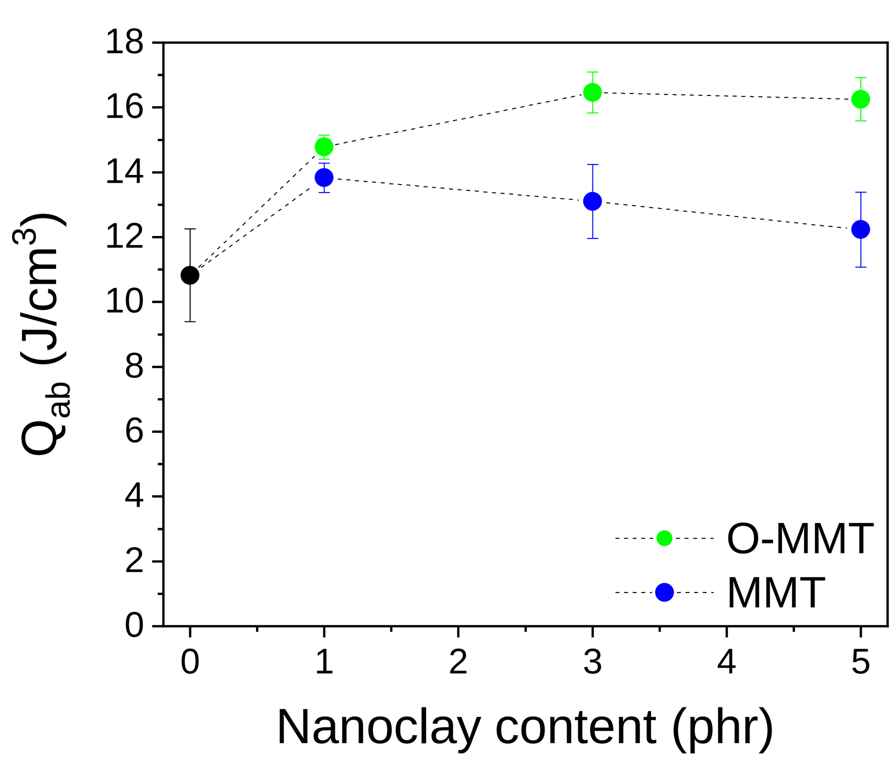
A : area of heat exchange; V: volume of material; h : heat transfer coefficient.

ELASTOCALORIC PROPERTIES

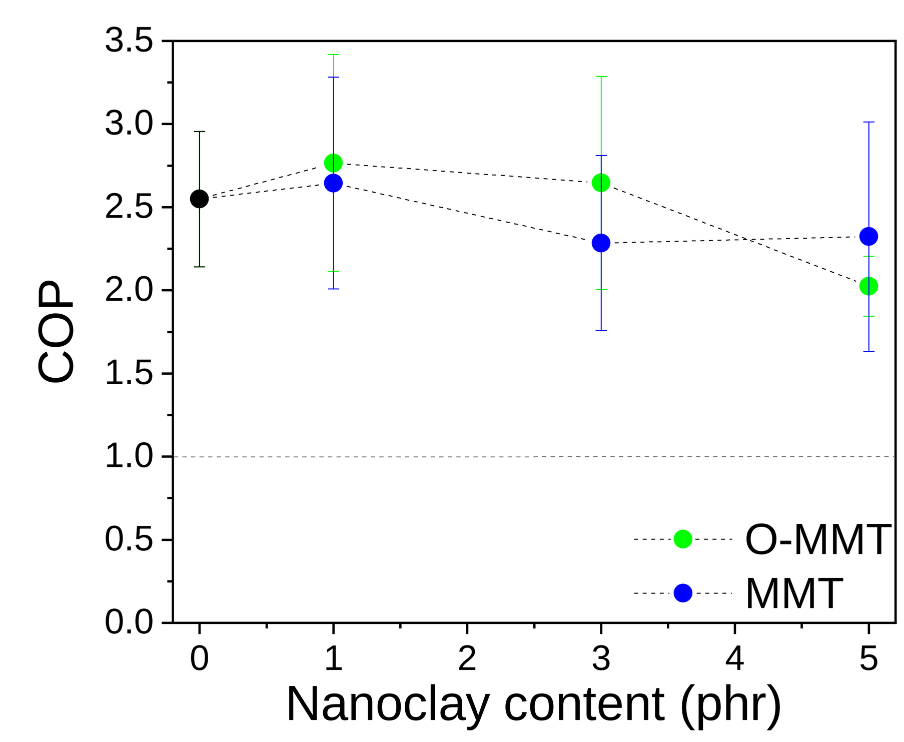
Maximum temperature change



Heat absorbed



COP



- **Compatibility rubber-filler** plays a **key role in the cooling performance**.
- **NR/O-MMT** nanocomposites show up to **45% ↑ in Q_{ab}** per refrigeration cycle with respect to unfilled NR.
- ↑ SIC, ↑ macromolecular structural homogeneity, and strain amplification effects→ better cooling performance.
- **MMT yields only marginal improvements** → poor dispersion and limited nanofiller-matrix interaction.