Determine Dielectric Constant in 1D Microwave Cavity

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Target

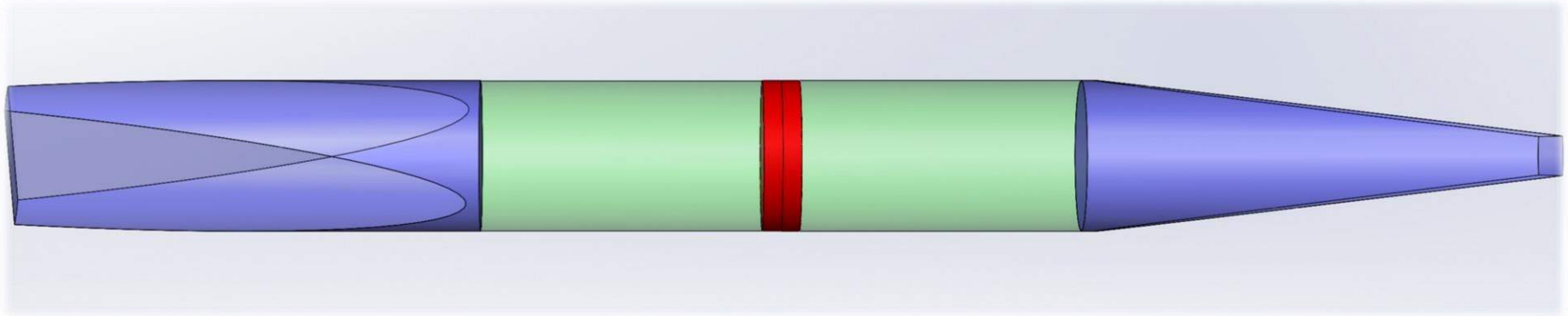
- Determine the complex dielectric constant of different mediums:
  1. NaCl, NH_4NO_3, KNO_3, $NaNO_3$, $KClO_3$ (humidity 0-10%)
  2. Mixture of two above (humidity 0-10%)
  3. Al powder
  4. Water
  5. Icing sugar (humidity 0-10%)
  6. Gasoline and diesel

According to DRDC’s contract section 6.5

Resonance method

- Frequency shift in 1D cavity:

  By writing down transmission matrix:

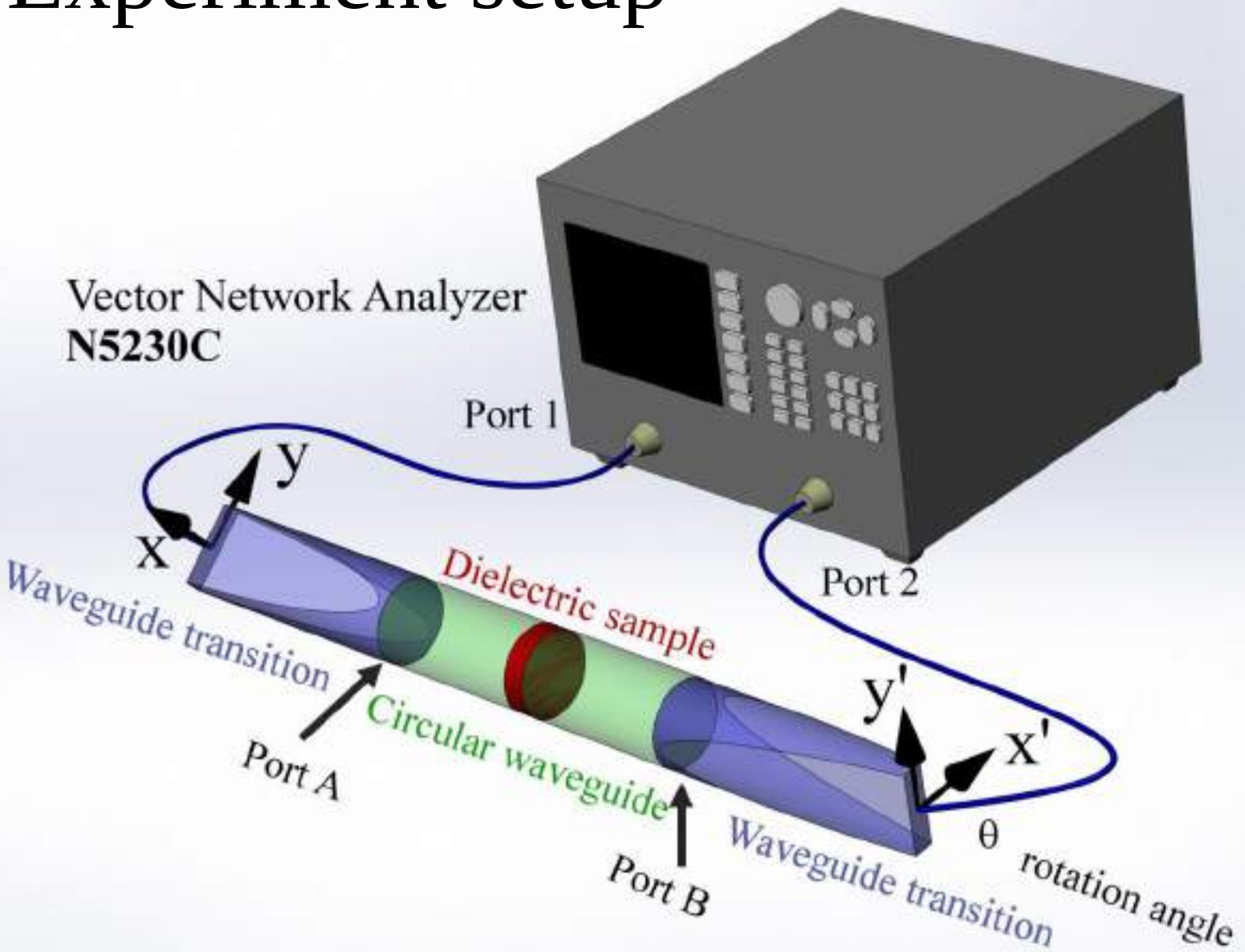


$$M_1 = \begin{pmatrix} A_1 & B_1 \\ C_1 & D_1 \end{pmatrix} \quad M_s = \begin{pmatrix} \cos(\beta_s l_s) & -i\, Z_s \sin(\beta_s l_s) \\ -i\, Z_s \sin(\beta_s l_s) & \cos(\beta_s l_s) \end{pmatrix} \quad M_2 = \begin{pmatrix} A_2 & B_2 \\ C_2 & D_2 \end{pmatrix}$$

$$M_{AB} = M_1 M_s M_2 \rightarrow S_{21}$$

Different sample will influence the M_s matrix ➔ S_{21}

Experiment setup



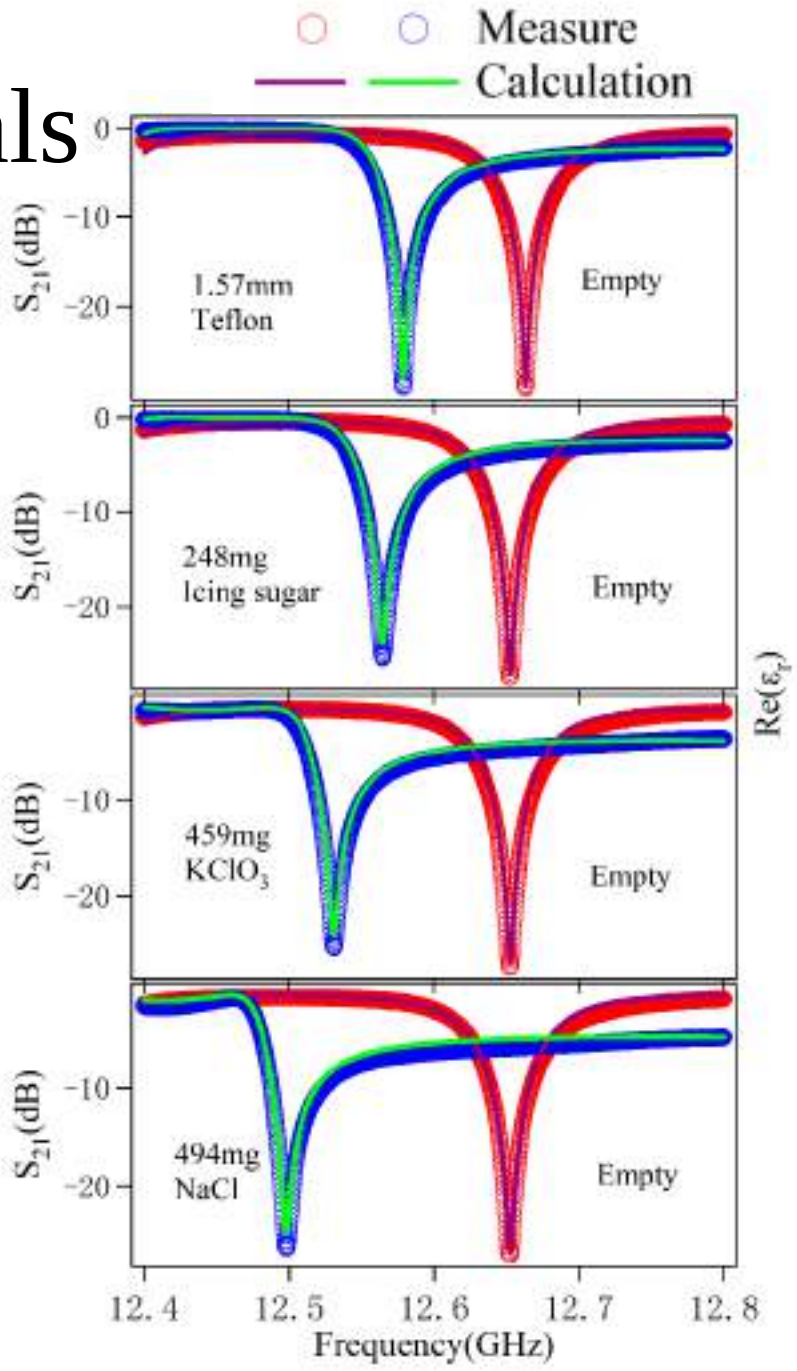
Pure materials

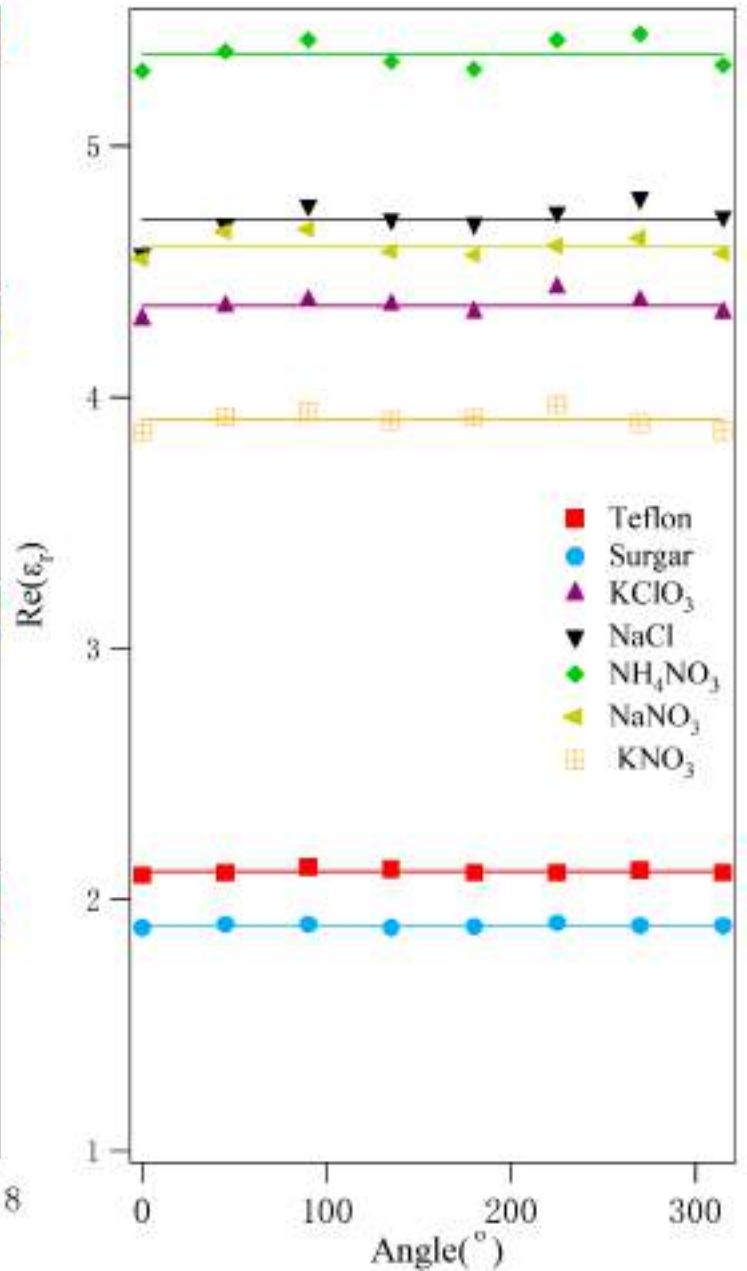
1.57mm Teflon

248mg icing sugar

459mg $KClO_3$

494mg NaCl

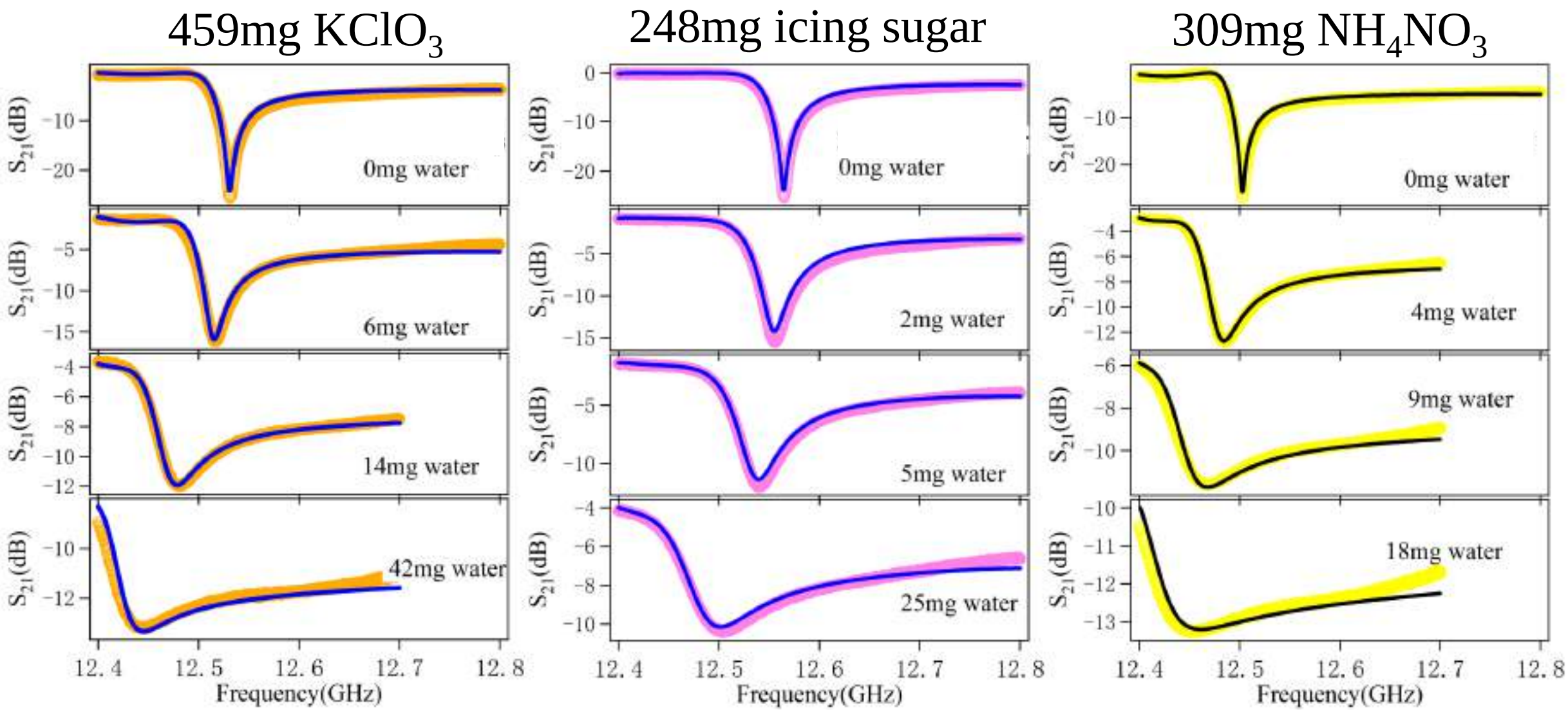




Icing sugar sample

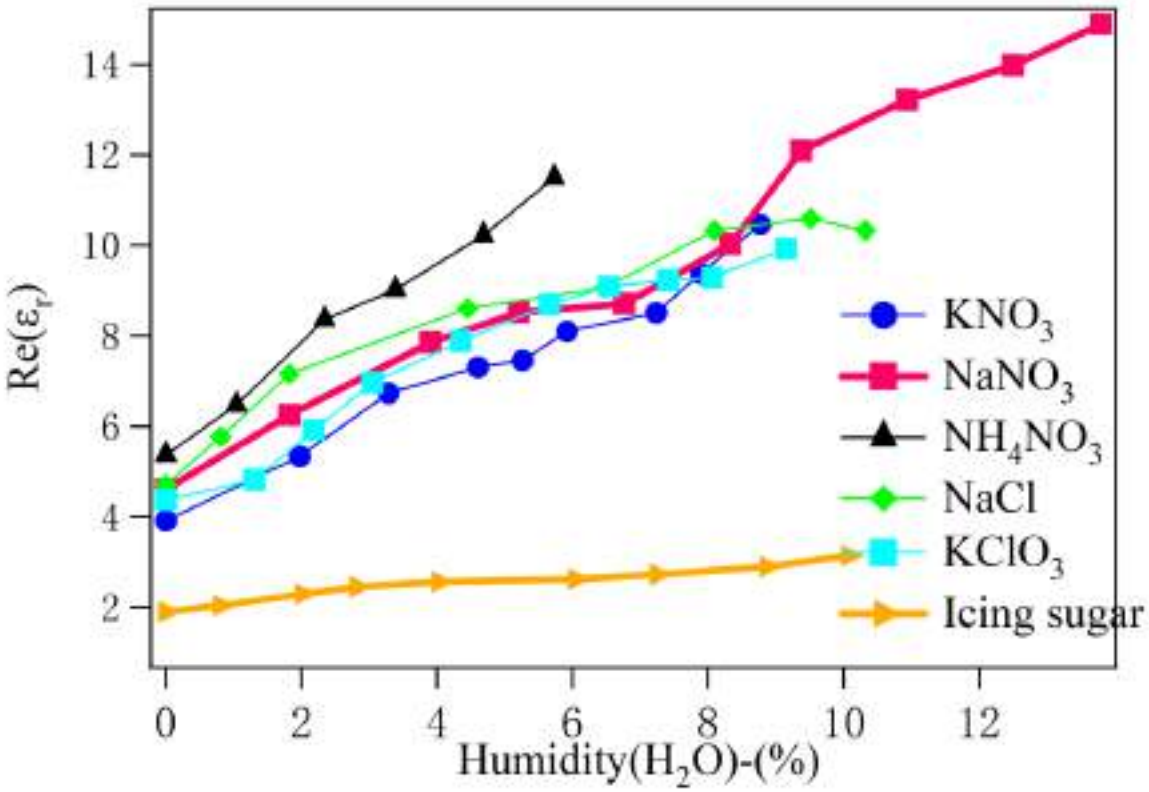
$NaNO_3$ sample

Spectra vs. humidity

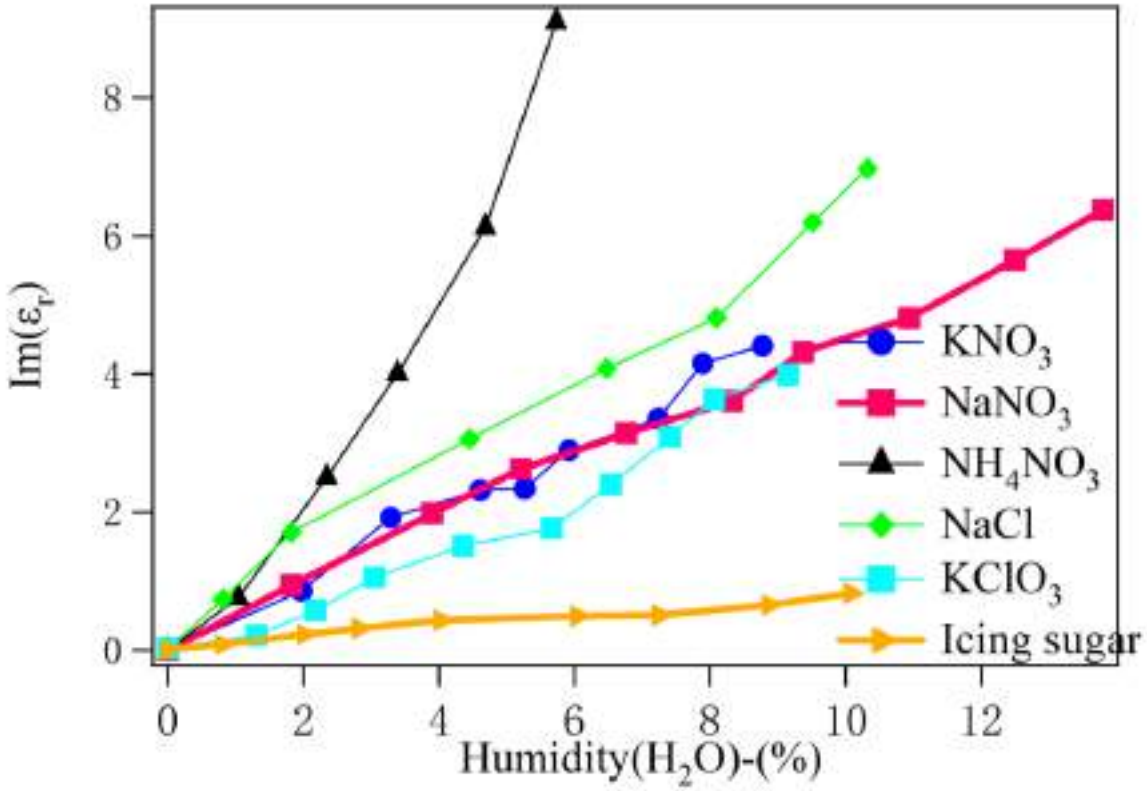


complex ε_r vs. humidity

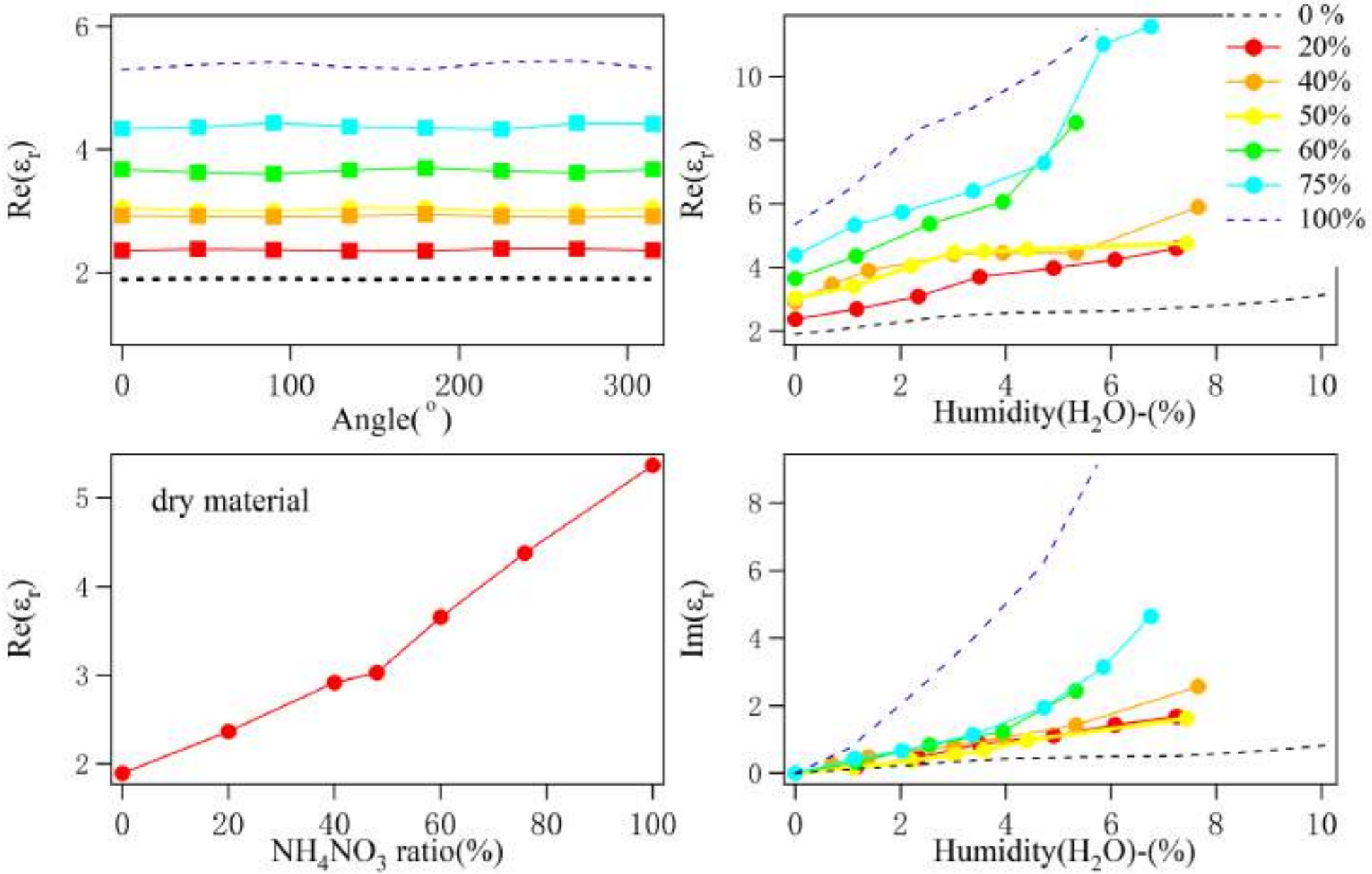
Real part



Imaginary part



Mixture: NH_4NO_3 in sugar(dry)



Progress (~ 80%)

Material	Data collection	Data analysis
NaCl	√	√
NH_4NO_3	√	√
KNO_3	√	√
$NaNO_3$	√	√
$KClO_3$	√	√
Mixture: icing sugar & NH_4NO_3	√	√
Mixture: $KClO_3$ & NH_4NO_3	In progress(40%)	---
Icing sugar	√	√
Al powder	√	√
Gasoline	√	In progress
Diesel	√	In progress
water	√	In progress