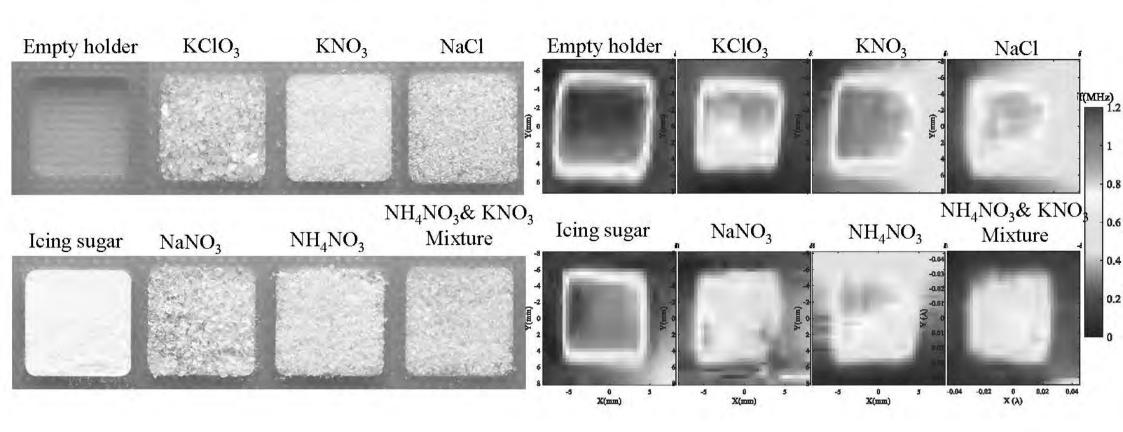
Progress on DRDC projects

Yutong Zhao Jan 7th 2019

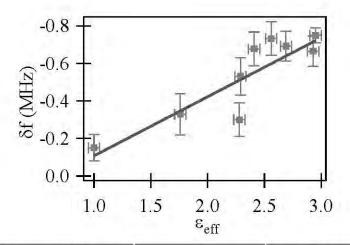
Optical image

Microwave image

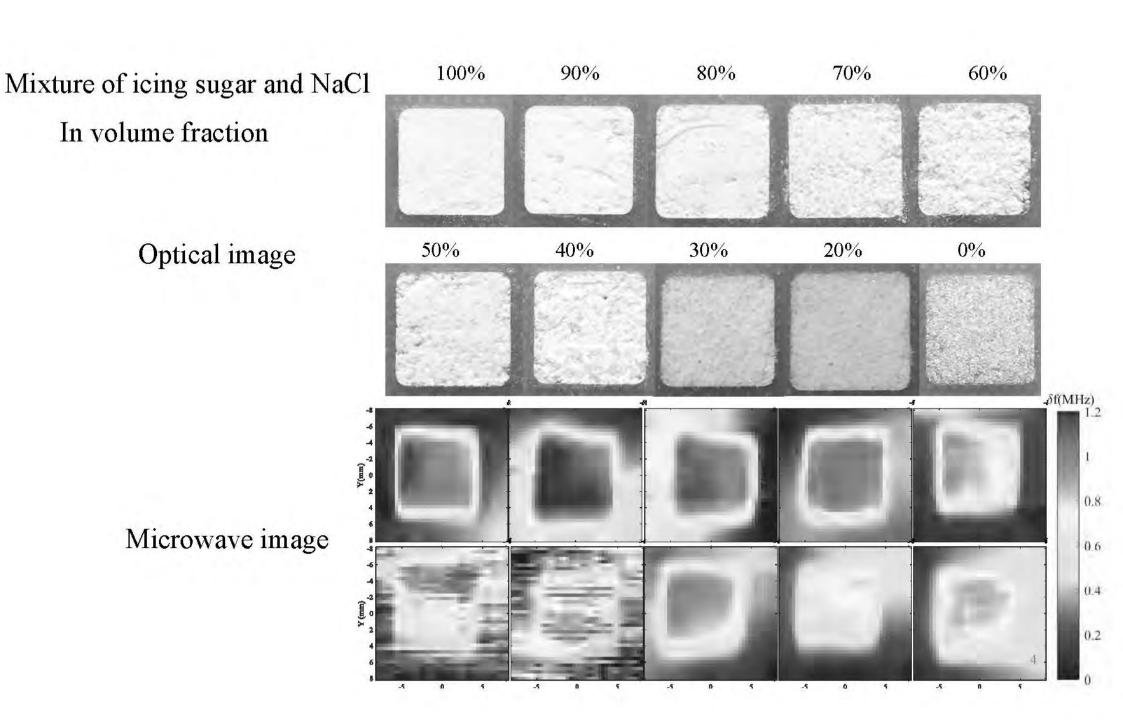


$$\frac{\delta f}{f_0} \approx \frac{\iiint_V \Delta \epsilon |E|^2 dv}{\iiint_V \epsilon |E|^2 dv} = \frac{\Delta \epsilon \cdot V}{\epsilon \cdot V}$$

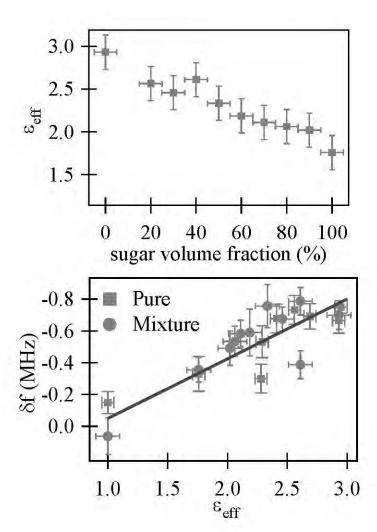
$$\frac{\Delta \epsilon_{eff} \cdot V}{\epsilon \cdot V} = \frac{\epsilon_{sample} V_{sample} + \epsilon_{air} V_{air}}{\epsilon_{air} (V_{sample} + V_{air})}$$



Materials	Sample mass(mg)	Density	Volume fraction	Permittivity(ϵ)	ϵ_{eff}	$-\delta \bar{f}(\mathrm{MHz})$
Air	0	~ 0	100%	~1	1	1.001
KClO ₃	79	2.32 g/cm ³	38.01%	4.36	2.28	0.852
KNO ₃	84	2.109 g/cm ³	44.27%	3.91	2.28	0.618
NaCl	102	2.17 g/cm^3	52.03%	4.71	2.95	0.485
NaNO ₃	95	2.257 g/cm ³	36.59%	4.60	2.69	0.418
NH ₄ NO ₃	56	1.72 g/cm ³	47.06%	5.37	2.56	0.458
Icing sugar	49	0.65 g/cm^3	84.27%	1.90	1.76	0.820
NH ₄ NO ₃ & KNO ₃ Mixture	68	1.94 g/cm ³	38.89%	4.63	2.41	0.472



Sugar Volume fraction(%)	Sample mass(mg)	ϵ_{eff}	$-\delta \bar{f}(\text{MHz})$	
0	101	2.93	0.450	
20	83	2.57	0.475	
30	78	2.46	0.763	
40	87	2.61	0.393	
50	73	2.33	0.560	
60	66	2.19	0.567	
70	63	2.11	0.616	
80	62	2.06	0.659	
90	62	2.02	0.794	
100	49	1.76	0.364	



First draft of the paper of dielectric imaging

Nunlinear split-ring resonator for near-field microwave imaging

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IN CONCLUSION

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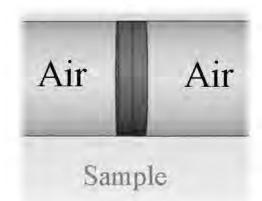
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Section 2. From University 12 and 12

Broadband method



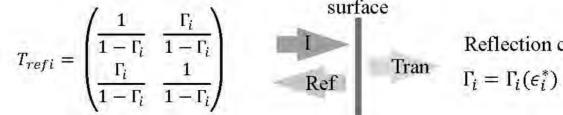
$$M_1 = x \cdot T_{ref_1} \cdot T_1 \cdot T_{ref_1}^{-1} \cdot y$$

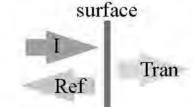


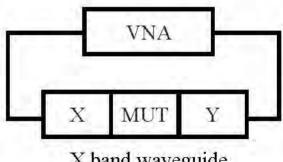
$$M_2 = x \cdot T_{ref_2} \cdot T_2 \cdot T_{ref_2}^{-1} \cdot y$$

Air
$$M_{i} = \begin{pmatrix} S_{12}^{i} - \frac{S_{11}^{i} S_{22}^{i}}{S_{21}^{i}} & \frac{S_{11}^{i}}{S_{21}^{i}} \\ -\frac{S_{21}^{i}}{S_{21}^{i}} & \frac{1}{S_{21}^{i}} \end{pmatrix}$$

$$T_i = \begin{pmatrix} e^{-\gamma_i d} & 0 \\ 0 & e^{\gamma_i d} \end{pmatrix}$$







X band waveguide

Tran Propagation constant
$$\gamma_i = \gamma_i(\epsilon_i^*)$$
 face

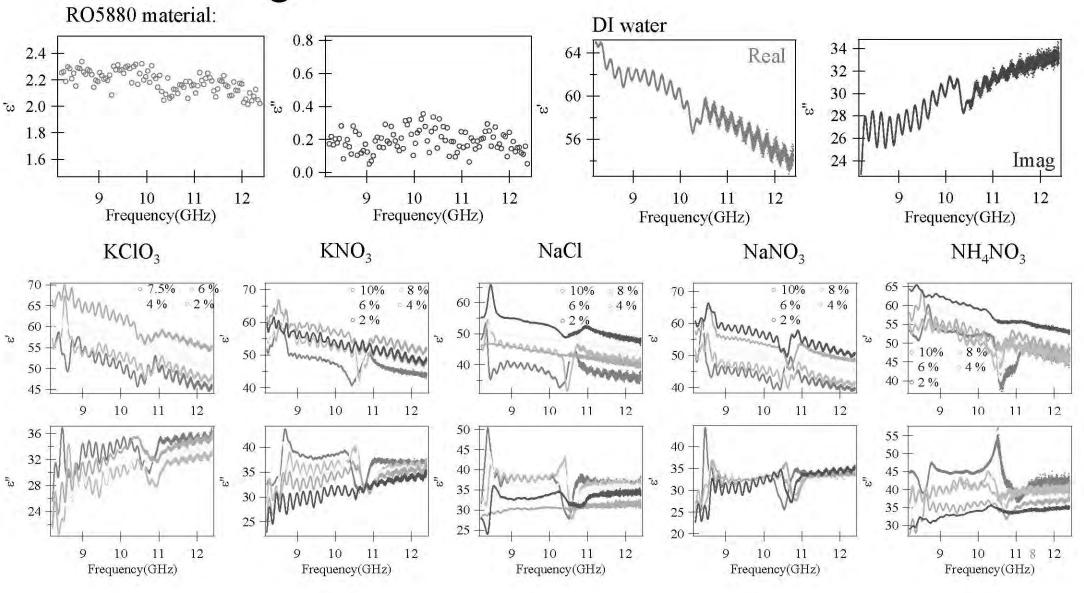
Reflection coefficient
$$\Gamma_i = \Gamma_i(\epsilon_i^*)$$

$$Tr(M_1M_2^{-1}) = Tr(T_{ref1}T_1T_{ref1}^{-1} \cdot T_{ref2}T_2^{-1}T_{ref2}^{-1})$$

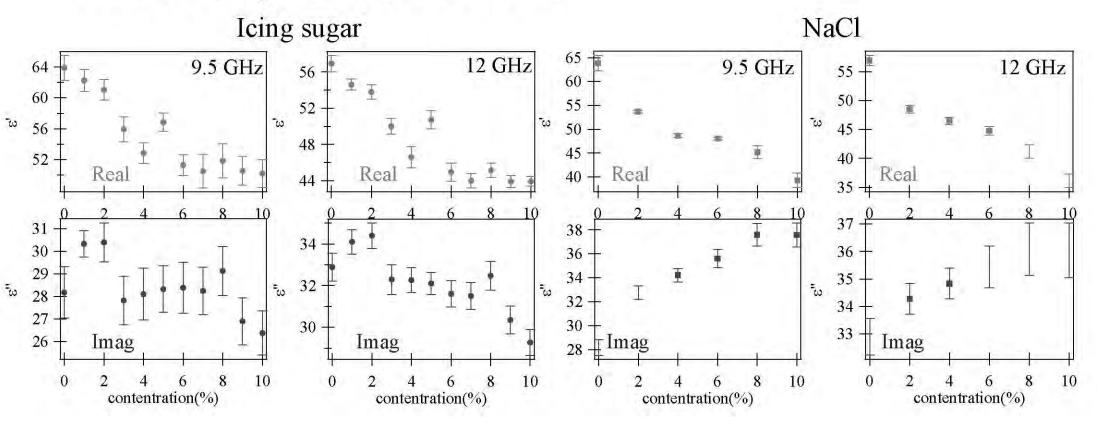
Solving the following equation

$$f(\epsilon) = Tr(LHS) - Tr(RHS) = 0$$

Results using broadband method



Summary of the results



$$\varepsilon(r) \simeq \frac{\varepsilon_{\text{DPB}}}{3h^2(l_h/r) + 1}$$

Dielectric Constant of Ionic Solutions: A Field-Theory Approach

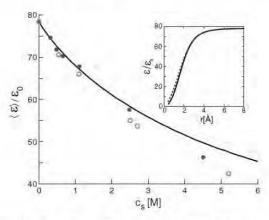


FIG. 1 (color online). The dielectric constant (\$\epsilon\$) averaged inside a specific volume around a single ion (solid line) as function of ionic concentration, c_3 . The comparison is done with experimental values for RbCl (empty circles) and CsCl (full circles) [19]. In the inset, the exact (solid line) and approximated [dashed line, Eq. (11)] solutions of the DPB equation (9) are shown as a function of the distance r from a point charge (ion). Choosing as a fit parameter the dipole moment of water to be $p_0 = 4.8$ D (instead of the physical value $p_0 = 1.8$ D) [23] allows us to obtain $\varepsilon_{\text{DPB}} = 80\varepsilon_0$ and $I_b \simeq 1.5$ Å.

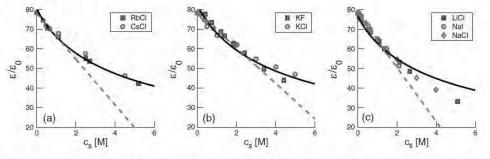
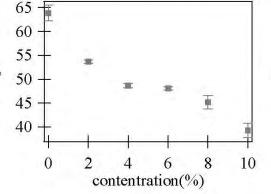
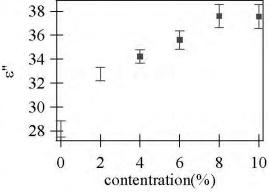


FIG. 2 (color online). Comparison of the predicted dielectric constant ε from Eq. (16), with experimental data from Ref. [19], as function of ionic concentration c_s for various salts. The theoretical prediction (solid line) was calculated using a as a fitting parameter. In (a) the fit is for RbCl and CsCl salts with a=2.66 Å; in (b) the fit is for KF and KCl with a=2.64 Å; while in (c) the fit is for LiCl, NaI, and NaCl with a=2.71 Å. The dashed lines are the linear fit to the data in the low $c_s \le 1$ M range. The slope of the linear fit is $\gamma/\varepsilon_0 = 11.7$ M⁻¹ in (a), 9.0 M⁻¹ in (b), and 13.8 M⁻¹ in (c). The value of γ for each salt varies by about 10–20% and the linear fit should be taken as representative of the low c_s behavior.

The dielectric constant (our measurement)





For this year's DRDC contract,

data collection: 95%

data analysis: 60%

report writing: 10%

Next step:

- 1. Determine the car gasoline and diesel using broadband method.
- 2. Summarize the rest of the data and fit with model.
- 3. Compare with the previous data.
- 4. Writing a report of these works.