

4/4/2025

500 Hz, 1000, 2000, 5000
10000, 20000

3000 Hz R = 100 kΩ

$$\text{f: } A = 0.00155 \pm 1.2 \times 10^{-4}$$

$$\omega = 19200 \pm 2.8$$

$$\phi = -1.39 \pm 0.16$$

$$C = 0.00660 \pm 8.8 \times 10^{-5}$$

$$\text{RMSE} = 0.0197$$

$$\text{f}_0: A = 0.201 \pm 0.022$$

$$\omega = 19200 \pm 2.7$$

$$\phi = -2.72 \pm 0.15$$

$$C = 0.00457 \pm 0.016$$

$$\text{RMSE} = 3.52$$

f = 7000 Hz R = 100 kΩ

$$\text{f: } A = -0.0115 \pm 7.3 \times 10^{-4}$$

$$\omega = 43700 \pm 2.2$$

$$\phi = 0.193 \pm 0.13$$

$$C = 0.0103 \pm 5.1 \times 10^{-4}$$

$$\text{RMSE} = 0.115$$

$$\text{f}_0: A = -0.353 \pm 0.022$$

$$\omega = 43700 \pm 2.2$$

$$\phi = -0.343 \pm 0.13$$

$$C = 0.00888 \pm 0.016$$

$$\text{RMSE} = 3.52$$

$R = 0.1 \text{ mS}$ Dry Ice temperature

80% sucrose solutions at 1.42 g water, 5.96 g sugar
stirred at 80% for 3 minutes

1 KHz

$$\cancel{\theta} = \cancel{0.639}$$

$$\cancel{w} = \cancel{6136}$$

$$\cancel{\phi} = \cancel{0.61}$$

$$\cancel{RMSE} = \cancel{3.5}$$

$$\cancel{\theta} = 4.99 \pm 2.1 \times 10^{-4}$$

$$\cancel{w} = 6280 \pm 0.015$$

$$\cancel{\phi} = 5.62 \pm 8.4 \times 10^{-5}$$

$$\cancel{C} = 0.00111 \pm 1.5 \times 10^{-4}$$

$$\cancel{RMSE} = \cancel{0.0106}$$

$$\theta = 0.0165 \pm 0.7 \times 10^{-5}$$

$$w = 6290 \pm 1.5$$

$$\phi = 0.673 \pm 0.0086$$

$$C = 0.0132 \pm 4.9 \times 10^{-5}$$

$$\underline{RMSE = 0.00348}$$

2 KHz

$$\theta = 4.99 \pm 3 \times 10^{-4}$$

$$w = 12600 \pm 0.041$$

$$\phi = 3.59 \pm 1.3 \times 10^{-4}$$

$$C = 0.00204 \pm 0.1 \times 10^{-4} \quad RMSE = 0.105$$

$$\theta = 0.0334 \pm 7.7 \times 10^{-5}$$

$$w = 12600 \pm 2$$

$$\phi = 4.7 \pm 0.0059$$

$$C = 0.0125 \pm 6.7 \times 10^{-5}$$

$$RMSE = 0.00348$$

$f = 5000 \text{ Hz}$

$$\left. \begin{array}{l} \ell_0 = 4.99 \pm 5.6 \times 10^{-4} \\ \omega = 31400 \pm 0.19 \\ \varphi = 4.01 \pm 2.3 \times 10^{-4} \\ C = 0.00589 \pm 3.9 \times 10^{-4} \\ \text{RMSE} = 0.0124 \end{array} \right\} \left. \begin{array}{l} \ell = 0.0026 \pm 1.7 \times 10^{-4} \\ \omega = 31400 \pm 4.6 \\ \varphi = 4.77 \pm 0.0053 \\ C = 0.013 \pm 1.2 \times 10^{-4} \\ \text{RMSE} = 0.00372 \end{array} \right.$$

$f = 10 \text{ kHz}$

$$\left. \begin{array}{l} \ell_0 = 5 \pm 4.1 \times 10^{-4} \\ \omega = 62800 \pm 0.28 \\ \varphi = -0.808 \pm 1.6 \times 10^{-4} \\ C = 0.00961 \pm 2.9 \times 10^{-4} \\ \text{RMSE} = 0.00648 \end{array} \right\} \left. \begin{array}{l} \ell = 0.0893 \pm 2.1 \times 10^{-4} \\ \omega = 62900 \pm 8 \\ \varphi = -0.493 \pm 0.0046 \\ C = 0.0127 \pm 1.5 \times 10^{-4} \\ \text{RMSE} = 0.00328 \end{array} \right.$$

$f = 20 \text{ kHz}$

$$\left. \begin{array}{l} \ell_0 = 4.98 \pm 8 \times 10^{-4} \\ \omega = 126000 \pm 0.56 \\ \varphi = 1.73 \pm 3.2 \times 10^{-4} \\ C = 0.0121 \pm 5.6 \times 10^{-4} \\ \text{RMSE} = 0.0126 \end{array} \right\} \left. \begin{array}{l} \ell = 0.107 \pm 2.2 \times 10^{-4} \\ \omega = 126000 \pm 7.1 \\ \varphi = 1.89 \pm 0.0041 \\ C = 0.0122 \pm 1.6 \times 10^{-4} \\ \text{RMSE} = 0.00346 \end{array} \right.$$

$f = 50 \text{ kHz}$

$$\left. \begin{array}{l} \ell_0 = 4.98 \pm 7.8 \times 10^{-4} \\ \omega = 126000 \pm 0.54 \\ \varphi = 4.52 \pm 3.1 \times 10^{-4} \\ C = 0.0110 \pm 5.5 \times 10^{-4} \\ \text{RMSE} = 0.0123 \end{array} \right\} \left. \begin{array}{l} \ell = 0.109 \pm 2.6 \times 10^{-4} \\ \omega = 126000 \pm 8.5 \\ \varphi = -1.58 \pm 0.0049 \\ C = 0.0119 \pm 1.8 \times 10^{-4} \\ \text{RMSE} = 0.00403 \end{array} \right.$$

$$R = 30\,000 \Omega, f = 20\, \text{kHz}$$

$$\beta_0 = -4.98 \pm 7.6 \times 10^{-4} \quad \left\{ \begin{array}{l} \beta = 0.1 \pm 2.4 \times 10^{-4} \\ \omega = 126000 \pm 0.53 \end{array} \right.$$

$$\omega = 126000 \pm 0.53 \quad \left\{ \begin{array}{l} \omega = 126000 \pm 8.4 \\ \varphi = -0.071 \pm 0.00005 \end{array} \right.$$

$$\varphi = -0.253 \pm 3 \times 10^{-4} \quad \left\{ \begin{array}{l} \varphi = -0.071 \pm 0.00005 \\ C = 0.0124 \pm 1.7 \times 10^{-4} \end{array} \right.$$

$$C = 0.0124 \pm 1.7 \times 10^{-4} \quad \left\{ \begin{array}{l} C = 0.0124 \pm 1.7 \times 10^{-4} \\ \text{RMSE} = 0.00386 \end{array} \right.$$

$$R = 30\,000 \Omega, f = 20\, \text{kHz}$$

$$\beta_0 = -4.98 \pm 7.6 \times 10^{-4} \quad \left\{ \begin{array}{l} \beta = 0.0987 \pm 2.3 \times 10^{-4} \\ \omega = 126000 \pm 8.2 \end{array} \right.$$

$$\omega = 126000 \pm 0.53 \quad \left\{ \begin{array}{l} \omega = 126000 \pm 8.2 \\ \varphi = 4.07 \pm 0.0048 \end{array} \right.$$

$$\varphi = -2.37 \pm 3.1 \times 10^{-4} \quad \left\{ \begin{array}{l} \varphi = 4.07 \pm 0.0048 \\ C = 0.0122 \pm 1.7 \times 10^{-4} \end{array} \right.$$

$$C = 0.0122 \pm 1.7 \times 10^{-4} \quad \left\{ \begin{array}{l} C = 0.0122 \pm 1.7 \times 10^{-4} \\ \text{RMSE} = 0.00370 \end{array} \right.$$

$$0.0119$$

Added 0.011F capacitor:

$$R = 30\, \text{k}\Omega, f = 20\, \text{kHz} \quad \left\{ \begin{array}{l} \beta = 0.118 \pm 2.5 \times 10^{-4} \\ \omega = 126000 \pm 7.4 \end{array} \right.$$

$$\beta_0 = 4.98 \pm 7.8 \times 10^{-4} \quad \left\{ \begin{array}{l} \beta = 0.118 \pm 2.5 \times 10^{-4} \\ \omega = 126000 \pm 7.4 \end{array} \right.$$

$$\omega = 126000 \pm 0.55 \quad \left\{ \begin{array}{l} \omega = 1.74 \pm 0.0043 \\ \varphi = 1.66 \pm 3.1 \times 10^{-4} \end{array} \right.$$

$$\varphi = 1.66 \pm 3.1 \times 10^{-4} \quad \left\{ \begin{array}{l} \varphi = 1.66 \pm 3.1 \times 10^{-4} \\ C = 0.0130 \pm 1.8 \times 10^{-4} \end{array} \right.$$

$$C = 0.0130 \pm 1.8 \times 10^{-4} \quad \left\{ \begin{array}{l} C = 0.0130 \pm 1.8 \times 10^{-4} \\ \text{RMSE} = 0.00397 \end{array} \right.$$

$$\text{RMSE} = 0.0123$$

$$R = 50 \text{ m}\Omega, f = 20 \text{ kHz}$$

$$\begin{aligned} k_0 &= 4.98 \pm 7.6 \times 10^{-4} & \left\{ \begin{array}{l} k = 0.12 \pm 2.4 \times 10^{-4} \\ \omega = 126000 \pm 0.53 \end{array} \right. \\ \omega &= 126000 \pm 0.53 & \left. \begin{array}{l} \omega = 126000 \pm 0.8 \\ \varphi = 2.3 \pm 0.0039 \end{array} \right. \\ \varphi &= 2.23 \pm 3 \times 10^{-4} & \left. \begin{array}{l} \varphi = 2.3 \pm 0.0039 \\ C = 0.0124 \pm 1.7 \times 10^{-4} \end{array} \right. \\ C &= 0.0133 \pm 5.4 \times 10^{-4} & \left. \begin{array}{l} C = 0.0124 \pm 1.7 \times 10^{-4} \\ \text{RMSE} = 0.00374 \end{array} \right. \\ \text{RMSE} &= 0.012 & \end{aligned}$$

$$R = 0.1 \text{ m}\Omega, f = 20 \text{ kHz}$$

$$\begin{aligned} k_0 &= 4.98 \pm 8.1 \times 10^{-4} & \left\{ \begin{array}{l} k = 0.17 \pm 2.2 \times 10^{-4} \\ \omega = 126000 \pm 0.57 \end{array} \right. \\ \omega &= 126000 \pm 0.57 & \left. \begin{array}{l} \omega = 126000 \pm 0.5 \\ \varphi = -1.47 \pm 0.0038 \end{array} \right. \\ \varphi &= 4.73 \pm 3.3 \times 10^{-4} & \left. \begin{array}{l} \varphi = -1.47 \pm 0.0038 \\ C = 0.0127 \pm 1.6 \times 10^{-4} \end{array} \right. \\ C &= 0.0136 \pm 5.8 \times 10^{-4} & \left. \begin{array}{l} C = 0.0127 \pm 1.6 \times 10^{-4} \\ \text{RMSE} = 0.00347 \end{array} \right. \\ \text{RMSE} &= 0.0128 & \end{aligned}$$

$$R = 0.1 \text{ m}\Omega, f = 10 \text{ kHz}$$

$$\begin{aligned} k_0 &= 4.98 \pm 5.1 \times 10^{-4} & \left\{ \begin{array}{l} k = 0.103 \pm 2.3 \times 10^{-4} \\ \omega = 62800 \pm 0.36 \end{array} \right. \\ \omega &= 62800 \pm 0.36 & \left. \begin{array}{l} \omega = 62800 \pm 7.8 \\ \varphi = 4.59 \pm 0.0045 \end{array} \right. \\ \varphi &= 4.25 \pm 2.1 \times 10^{-4} & \left. \begin{array}{l} \varphi = 4.59 \pm 0.0045 \\ C = 8.47 \times 10^{-5} \pm 1.6 \times 10^{-4} \end{array} \right. \\ C &= 0.0105 \pm 3.6 \times 10^{-4} & \left. \begin{array}{l} C = 8.47 \times 10^{-5} \pm 1.6 \times 10^{-4} \\ \text{RMSE} = 0.00365 \end{array} \right. \\ \text{RMSE} &= 0.00811 & \end{aligned}$$

$$R = 0.1 \text{ m}\Omega, f = 50000 \text{ Hz}$$

$$\begin{aligned} k_0 &= 4.96 \pm 6.7 \times 10^{-4} & \left\{ \begin{array}{l} k = 0.114 \pm 1.7 \times 10^{-4} \\ \omega = 314000 \pm 2.6 \end{array} \right. \\ \omega &= 314000 \pm 0.23 & \left. \begin{array}{l} \omega = 314000 \pm 2.6 \\ \varphi = -1.8 \pm 0.003 \end{array} \right. \\ \varphi &= -1.48 \pm 2.7 \times 10^{-4} & \left. \begin{array}{l} \varphi = -1.8 \pm 0.003 \\ C = 0.00128 \pm 1.2 \times 10^{-4} \end{array} \right. \\ C &= 0.0019 \pm 4.7 \times 10^{-4} & \left. \begin{array}{l} C = 0.00128 \pm 1.2 \times 10^{-4} \\ \text{RMSE} = 0.00385 \end{array} \right. \\ \text{RMSE} &= 0.0179 & \end{aligned}$$

$$R = 0.1 \text{ M}\Omega, f = 5 \text{ kHz}$$

$$k_0 = 4.99 \pm 5.6 \times 10^{-4}$$

$$\omega = 31400 \pm 0.19$$

$$\varphi = 4.87 \pm 2.2 \times 10^{-4}$$

$$c = 0.00651 \pm 3.9 \times 10^{-4}$$

$$\text{RMSE} = 0.0129$$

$$k = 0.0853 \pm 1.7 \times 10^{-4}$$

$$\omega = 31400 \pm 3.4$$

$$\varphi = 556 \pm 0.0038$$

$$c = -0.00102 \pm 1.2 \times 10^{-4}$$

$$\text{RMSE} = 0.00370$$

$$R = 0.1 \text{ M}\Omega, f = 2 \text{ kHz}$$

$$k_0 = 4.99 \pm 3 \times 10^{-4}$$

$$\omega = 12600 \pm 0.041$$

$$\varphi = 0.145 \pm 1.2 \times 10^{-4}$$

$$c = 0.00267 \pm 2.1 \times 10^{-4}$$

$$\text{RMSE} = 0.0105$$

$$k = 0.0448 \pm 1 \times 10^{-4}$$

$$\omega = 12600 \pm 1.6$$

$$\varphi = 1.26 \pm 0.0047$$

$$c = -1.49 \times 10^{-4} \pm 7.4 \times 10^{-5}$$

$$\text{RMSE} = 0.00370$$

$$R = 0.1 \text{ M}\Omega, f = 2 \text{ kHz}$$

$$k_0 = \cancel{4.99} \pm 2.1 \times 10^{-4} \quad k = 0.0259 \pm 7.6 \times 10^{-5}$$

$$\omega = 6280 \pm 0.015$$

$$\varphi = 5.29 \pm 8.5 \times 10^{-5}$$

$$c = 7.19 \times 10^{-4} \pm 1.5 \times 10^{-4}$$

$$\text{RMSE} = 0.0107$$

$$\omega = 6280 \pm 1$$

$$\varphi = 0.331 \pm 0.0059$$

$$c = -1.78 \times 10^{-4} \pm 5.3 \times 10^{-5}$$

$$\text{RMSE} = 0.00378$$