Aprēķini

(2.) Aprēķināt optiski aktīvās vielas īpatnējo griešanas spēju pie visām nomērītajām koncentrācijām.

$$\boxed{[\alpha] = \frac{\varphi}{Cl}}$$

$$[\alpha]_{C=0} = 0\ \frac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$$

$$[\alpha]_{C=20} = \frac{-1{,}6}{20 \cdot 9{,}504} \approx -0{,}0082\ \frac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$$

$$[\alpha]_{C=40} \approx -0{,}0089\ \frac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$$

$$[\alpha]_{C=60} \approx -0{,}0083\ \frac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$$

$$[\alpha]_{C=80} \approx -0{,}0084\ \frac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$$

$$[\alpha]_{C=100} \approx -0{,}0082\ \frac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$$

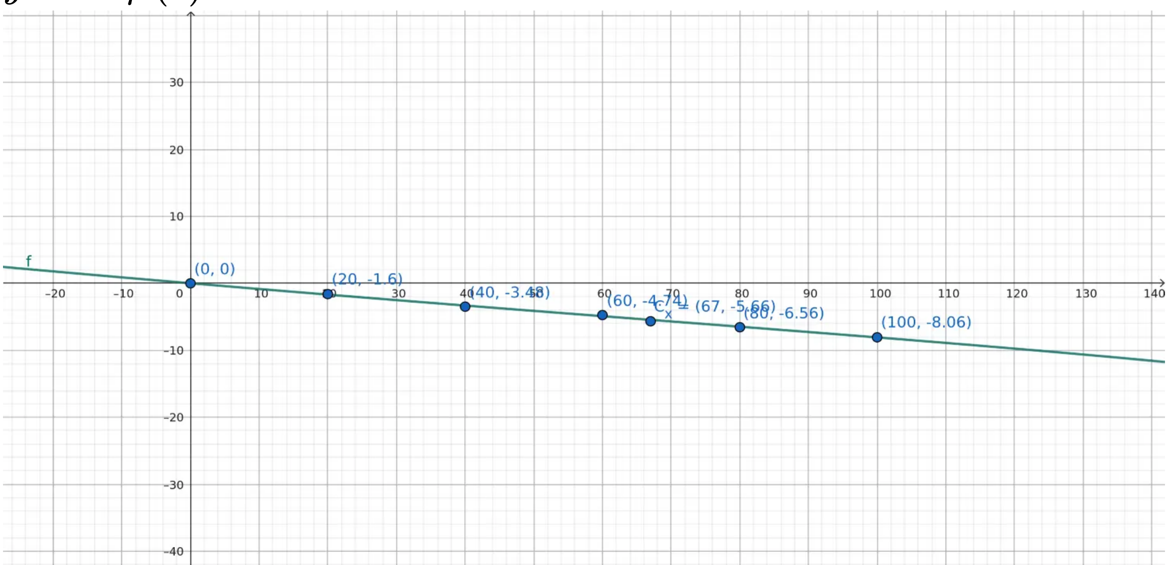
(3.) Noteikt optiski aktīvās vielas šķīduma nezināmo koncentrāciju grafiski un analītisk

$$C_x = \frac{\varphi_x}{\overline{[\alpha]_{C\neq 0}} \cdot l} = \frac{-5{,}66}{0{,}0084 \cdot 9{,}804} \approx 69{,}249\ \frac{\mathrm{mg}}{\mathrm{cm}^3}$$

φ atkarība no C

x ass – $C\left(\frac{\mathrm{mg}}{\mathrm{cm}^3}\right)$

y ass – $\varphi\,(^\circ)$



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4. Kļūdu aprēķini

β_0, β_x, l ir tiešo mērījumu kļūdas.
$[\alpha]$ ir netiešo mērījumu kļūda.
$\delta l = 0{,}005$ mm

$$\overline{\beta_0} = \frac{1}{5}\sum_{i=1}^{5} \beta_{0,\,i} = -0{,}14^\circ$$

$$S_{\beta_0} = \sqrt{\frac{\sum_{i=1}^{5}(\overline{\beta_0} - \beta_{0,\,i})^2}{5 \cdot 4}} = 0{,}0316$$

$$\Delta\left(\beta_0\right)_{\text{gad.}} = S_{\beta_0} \cdot t_{0{,}95}(5) = 0{,}0316 \cdot 2{,}78 \approx 0{,}0879$$

$$\Delta\left(\beta_0\right)_{\text{sist.}} = \frac{t_{0{,}95}(\infty)}{3} \cdot \delta\beta = \frac{1{,}96}{3} \cdot 0{,}1 = 0{,}0653$$

$$\Delta\beta_0 = \sqrt{\left(\Delta\left(\beta_0\right)_{\text{gad.}}\right)^2 + \left(\Delta\left(\beta_0\right)_{\text{sist.}}\right)^2} = 0{,}1095$$

$$\varepsilon(\beta_0) = \left|\frac{\Delta\beta_0}{\overline{\beta_0}}\right| = 73{,}02\%$$

$$\boxed{\beta_0 = (-0,14 \pm 0,1095)^\circ \text{ pie } \beta = 0,95,\ \varepsilon(\beta_0) = 73,02\%}$$

$$\overline{\beta_x} = \frac{1}{5}\sum_{i=1}^{5} \beta_{x,\,i} = -5{,}825^\circ$$

$$S_{\beta_x} = \sqrt{\frac{\sum_{i=1}^{5}(\overline{\beta_x} - \beta_{x,\,i})^2}{5 \cdot 4}} = 0{,}0428$$

$$\Delta\left(\beta_x\right)_{\text{gad.}} = S_{\beta_x} \cdot t_{0{,}95}(5) = 0{,}119$$

$$\Delta\left(\beta_x\right)_{\text{sist.}} = \frac{t_{0{,}95}(\infty)}{3} \cdot \delta\beta = 0{,}0653$$

$$\Delta\beta_x = \sqrt{\left(\Delta\left(\beta_x\right)_{\text{gad.}}\right)^2 + \left(\Delta\left(\beta_x\right)_{\text{sist.}}\right)^2} = 0{,}1358$$

$$\varepsilon(\beta_x) = \left|\frac{\Delta\beta_x}{\overline{\beta_x}}\right| = 2{,}33\%$$

$$\boxed{\beta_x = (-5{,}825 \pm 0{,}1358)^\circ \text{ pie } \beta = 0{,}95,\ \varepsilon(\beta_x) = 2,33\%}$$

$$\Delta l = \sqrt{(\Delta l_{\text{sist.}})^2} = \frac{t_{0{,}95}(\infty)}{3} \cdot \delta l \approx 0{,}0033$$

$$\varepsilon(l) = \frac{0{,}0033}{9{,}504} \approx 0,03\%$$

$$\boxed{l = (9,504 \pm 0,0033) \text{ cm pie } \beta = 0,95,\ \varepsilon(l) = 0,03\%}$$

$\varphi_x = \beta_x - \beta_0$ (Netiešo mērījumu kļūda, daļa no $[\alpha]$ kļūdu aprēķina)

$$\overline{\varphi_x} = \overline{\beta_x} - \overline{\beta_0} = -5{,}66$$

$$\Delta\varphi_x = \sqrt{\left(\frac{\partial\varphi_x}{\partial\beta_x}\right)^2 + \left(\frac{\partial\varphi_x}{\partial\beta_0}\right)^2} = \sqrt{(\Delta\beta_x)^2 + (-\Delta\beta_0)^2} = \sqrt{0{,}1358^2 + (-0{,}1095)^2} \approx$$
$$\approx 0{,}1744$$
$$\varepsilon(\varphi_x) = \left|\frac{\Delta\varphi_x}{\overline{\varphi_x}}\right| = 3{,}08\%$$
$$\boxed{\varphi_x = (-5{,}66 \pm 0{,}1744)^\circ \text{ pie } \beta = 0,95, \varepsilon(\varphi_x) = 3,08\%}$$

$$C_x = \frac{\varphi_x}{\overline{[\alpha]_{C\neq 0}} \cdot l} \quad \text{(Netiešo mērījumu kļūda, daļa no } [\alpha] \text{ kļūdu aprēķina)}$$
$$\Delta C_x = \sqrt{(\Delta(C_x)_{\varphi_x})^2 + (\Delta(C_x)_{[\alpha]})^2 + (\Delta(C_x)_l)^2}$$
Tā kā veidojas formulu rekursija, pieņemsim, ka $\Delta(C_x)_{[\alpha]} = 0$
$$\Delta(C_x)_{\varphi_x} = \frac{\partial C_x}{\partial\varphi_x} \cdot \Delta\varphi_x = \frac{1}{\overline{[\alpha]} \cdot l} \cdot 0{,}1744 = \frac{0{,}1744}{-0{,}0084 \cdot 9{,}504} \approx -2{,}1845$$
$$\Delta(C_x)_l = \frac{\partial C_x}{\partial l} \cdot \Delta l = \frac{-\varphi_x}{\overline{[\alpha]} \cdot l^2} \cdot 0{,}0033 = \frac{5{,}66 \cdot 0{,}0033}{-0{,}0084 \cdot 9{,}504^2} \approx -0{,}0246$$
$$\Delta C_x = \sqrt{(-2{,}1845)^2 + (-0{,}0246)^2} \approx 2{,}1846$$
$$\varepsilon(C_x) = \frac{\Delta C_x}{C_x} = \frac{2{,}1846}{69{,}249} \approx 3{,}15\%$$
$$\boxed{C_x = (69{,}249 \pm 2{,}1846)\frac{\text{mg}}{\text{cm}^3} \text{ pie } \beta = 0{,}95,\ \varepsilon(C_x) = 3{,}15\%}$$

$$[\alpha] = \frac{\varphi}{C \cdot l} \quad \text{(Netiešo mērījumu kļūda)}$$
$$\overline{[\alpha]} = \frac{1}{5}\sum_{i=1}^{5} [\alpha]_i = -0{,}0084\ \frac{^\circ \cdot \text{cm}^2}{\text{mg}}$$
$$\Delta[\alpha] = \sqrt{(\Delta[\alpha]_{\varphi_x})^2 + (\Delta[\alpha]_{C_x})^2 + (\Delta[\alpha]_l)^2}$$
$$\Delta[\alpha]_{\varphi_x} = \frac{\partial[\alpha]}{\partial\varphi_x} \cdot \Delta\varphi_x = \frac{\Delta\varphi_x}{C_x \cdot l} = \frac{0{,}1744}{69{,}249 \cdot 9{,}504} \approx 2{,}6499 \cdot 10^{-4}$$
$$\Delta[\alpha]_{C_x} = \frac{\partial[\alpha]}{\partial C_x} \cdot \Delta C_x = \frac{-\varphi_x \cdot \Delta C_x}{(C_x)^2 \cdot l} = \frac{5{,}66 \cdot 2{,}1846}{69{,}249^2 \cdot 9{,}504} \approx 2{,}713 \cdot 10^{-4}$$
$$\Delta[\alpha]_l = \frac{\partial[\alpha]}{\partial l} \cdot \Delta l = \frac{-\varphi_x \cdot \Delta C_x}{C_x \cdot l^2} = \frac{5{,}66 \cdot 2{,}1846}{69{,}249 \cdot 9{,}504^2} \approx 1{,}9768 \cdot 10^{-3}$$
$$\Delta[\alpha] = \sqrt{(2{,}6499 \cdot 10^{-4})^2 + (2{,}713 \cdot 10^{-4})^2 + (1{,}9768 \cdot 10^{-3})^2} \approx 0{,}002$$
$$\varepsilon[\alpha] = \left|\frac{\Delta[\alpha]}{\overline{[\alpha]}}\right| = \left|\frac{0{,}002}{-0{,}0084}\right| \approx 23{,}81\%$$
$$\boxed{[\alpha] = (-0{,}0084 \pm 0{,}002)\ \frac{^\circ \cdot \text{cm}^2}{\text{mg}} \text{ pie } \beta = 0{,}95,\ \varepsilon[\alpha] = 23{,}81\%}$$

5. Secinājumi

Teorētiski pētamā viela ir fruktoze, kuras $[\alpha] = -0{,}00922\,\dfrac{^\circ \cdot \mathrm{cm}^2}{\mathrm{mg}}$, bet eksperimentāli tika noskaidrots, ka $[\alpha] \in [-0{,}0086; -0{,}0082]$. Teorētiskā vērtība neietilpst šajā intervālā, bet atrodas tam tuvumā, tāpēc var pieļaut, ka viela tiešām ir fruktoze. Rezultātus varēja ietekmēt nepietiekama precizitāte, jo pusi no mērījumiem ir veicis cilvēks ar redzes problēmām – daltonismu un daļēji samazinātu krāsu uztverumu