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Effect of Sugar Addition on the Electric Current Strength of Mixtures with Vinegar, Lime Extract, Coffee, Salt Solution, and 70% Alcohol

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ABSTRACT

This study aims to examine the electric current strength of sugar mixed with various electrolyte and non-electrolyte solutions. The research employed an experimental approach using vinegar, lime extract, coffee solution, salt solution, and 70% alcohol combined with sugar solutions. A battery system and a digital multimeter were utilized to measure the resulting current in each mixture. The findings indicate that increasing the amount of sugar leads to a reduction in current strength, whereas decreasing the sugar content results in a higher current output.

Keywords: Electrical conductivity, Sugar solution, Electrolyte mixture, Current strength

1. INTRODUCTION

A solution is defined as a homogeneous mixture composed of two or more substances with varying compositions.[1] It is considered homogeneous because every part of the mixture exhibits a uniform composition and shows no observable differences among its components, even when examined under an optical microscope. In a solution, the solvent is the component present in a larger amount, usually in the liquid phase, while the solute may be a solid, liquid, or gas present in a smaller proportion. The interaction between the solvent and the solute not only produces a uniform mixture but also leads to changes in several physical properties of the pure solvent.[2, 3]

When a solute is introduced into a solvent, the physical properties of the pure solvent undergo modifications. Properties such as boiling point, freezing point, and vapor pressure may increase or decrease depending on the number of solute particles present in the solution.[4] These changes form an important foundation for understanding the behavior of solutions, including their ability or inability to conduct electric current.

Based on this characteristic, solutions are classified into two main categories, namely electrolyte solutions and non-electrolyte solutions.[5, 6] Electrolyte solutions contain free ions that originate from the dissociation of acids, bases, or salts. Strong acids ionize completely and generate a large number of ions, while weak acids ionize only partially and therefore produce fewer ions. The stronger the acidity of a solution, the lower its pH value tends to be.[7, 8] The presence of free-moving ions enables electrolyte solutions to conduct electricity, which can be observed through the illumination of a test lamp or the formation of bubbles at the electrodes.[9, 10] In contrast, non-electrolyte solutions do not conduct electric current because their constituent molecules do not undergo ionization in solution. Without charged ions, there are no mobile charge carriers that can facilitate the flow of electric current.[11, 12] Examples of non-electrolyte solutions include drinking water, urea solution, and sugar solution. Sugar solution is categorized as a non-electrolyte solution because sugar molecules do not dissociate into ions when dissolved in water.[13, 14] The absence of ions results in very low electrical conductivity compared to electrolyte solutions such as salt or acid solutions. Furthermore, increasing the concentration of sugar in water reduces the electrical conductivity even more, as the rising number of non-ionic molecules limits the presence and mobility of any ions in the system.

Understanding the conductivity behavior of sugar solutions is important for studies related to solution properties, chemistry education experiments, and applications involving electrolyte and non-electrolyte concepts in everyday life. Therefore, the present study focuses on examining the electrical conductivity of sugar solutions at various concentration levels in order to strengthen the fundamental understanding of non-electrolyte solution behavior.

2. EXPERIMENTAL

2.1. Materials and Tools

The materials used in this study consisted of vinegar, lime extract, coffee powder, ethanol (70%), fine salt, and sugar. The instruments employed to measure the electrical current of the solutions included a researcher-assembled electrical circuit and a handheld digital multimeter (DT-830D, model I2041). Several simple supporting items, such as small cups and containers, were also utilized to prepare and mix the solutions during the experimental procedure.

Figure 1. Setup for measuring current in sugar–solution mixtures.

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2.2. Research Procedure

2.2.1. Construction of the Conductor Device

To construct the conductor, two copper wires of equal length are first prepared by cutting them with scissors. A plastic straw is then trimmed into small sections to serve as insulating components. One piece of copper wire is tightly coiled around a dropper approximately five times, leaving a section of exposed wire that functions as a tail. The second copper wire is wrapped in the same manner, also forming a similar exposed tail, resulting in two coiled conductors ready for use in the experimental setup.

2.2.2. Assembly of the Measurement Circuit

To assemble the measuring circuit, a multimeter equipped with two test leads is first prepared by connecting the black (negative) lead to the port labeled "COM" and the red (positive) lead to the port labeled "V-mA." The 9-volt battery is then fitted with a battery clip. The red crocodile-clip lead is connected from the positive terminal of the battery clip to the metal tip of the red multimeter probe. Similarly, the black crocodile-clip lead is connected from the negative terminal of the battery clip to one of the exposed wire "tails" of the conductance sensor. The remaining crocodile clips are attached to the second wire tail of the conductance sensor and to the black lead of the battery clip, completing the measurement circuit.

3. RESULTS AND DISCUSSION

3.1. Electrical Conductivity Response of Sugar-Solution Mixtures

The current–response profile shown in figure 1 reflects the electrochemical behavior of multiple sugar-solution systems under varying sucrose concentrations (8 g, 16 g, and 24 g).

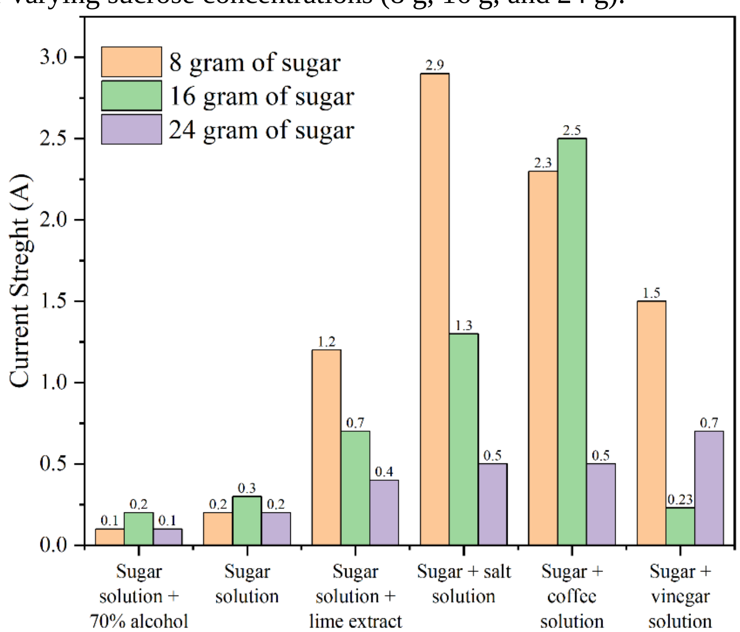

Figure 1. Current strength (A) of sugar–solution mixtures across different solution types

The data reveal that mixtures containing 8 g sucrose exhibit the highest measured current across most matrices, whereas the 24 g mixtures consistently display the lowest current output. This behavior is indicative of a systematic reduction in the density of charge carriers as sucrose concentration increases. Since sucrose is a molecular, non-dissociating species, its addition effectively decreases the ionic strength and lowers the overall charge–transport capacity of the medium.[15, 16]

At constant sucrose mass, significant differences in current intensity among the tested solutions reflect differences in their intrinsic electrolytic behavior. The salt solution (NaCl), a strong electrolyte that undergoes near-complete dissociation into solvated Na^+ and Cl^- ions, generated the highest current (2.9 A at 8 g sucrose). Coffee and vinegar exhibit intermediate conductivity due to the presence of partially ionizable organic acids and proton-donating constituents, whereas lime extract behaves as a weak electrolyte with limited ionization. Conversely, sucrose solution and 70% alcohol, both characterized by negligible ion dissociation and low dielectric constants, produced minimal currents (0.2 A and 0.1 A), consistent with their inherently low free - ion populations.[17, 18]

The conductivity attenuation with sucrose addition is particularly systematic in the lime, salt, and vinegar matrices. For these systems, increasing sucrose concentration substantially reduces the effective ionic mobility (μ) by lowering the number of solvated ions and increasing solution viscosity (η), which inversely affects ion transport according to the Stokes–Einstein framework. The salt system illustrates this effect most clearly: the current decreases sharply from 2.9 A (8 g) to 1.3 A (16 g) and further to 0.5 A (24 g), reflecting a strong dilution and mobility - suppression mechanism.[15, 16, 19]

A deviation from monotonic behavior is observed in the coffee system, where the current increases slightly from 2.3 A (8 g) to 2.5 A (16 g) before decreasing sharply to 0.5 A at 24 g. This transient enhancement suggests that moderate sucrose levels may improve the dispersion or solubilization of ionizable coffee constituents, transiently increasing ionic strength. However, at higher sucrose concentrations, the non-electrolyte dominating effect leads to a substantial reduction in ionic conductivity. Similar minor fluctuations in the sugar and sugar–alcohol systems (very low currents at all concentrations) are likely attributable to instrument sensitivity and contact–interface variability rather than true changes in ionic conduction.[16, 20]

From a physicochemical standpoint, these observations align with electrolyte theory. Sucrose does not dissociate in water, thereby contributing no increase in charge carrier density. Its increasing concentration leads to (i) reduced dielectric constant of the medium, (ii) increased viscosity, (iii) decreased ionic mobility, and (iv) dilution of existing ions-collectively suppressing current flow. In contrast, NaCl dissociation provides a high concentration of mobile ions, while vinegar and lime extract generate variable quantities of H^+ and organic anions. The extremely low conductivity of 70% alcohol is expected, as ethanol possesses a much lower dielectric constant than water and supports virtually no ionic dissociation.[20, 21]

Overall, the results demonstrate that the measured current is governed primarily by ionic strength, dielectric properties, viscosity, and ion mobility of the mixtures. Systems containing ionizable solutes exhibit high conductivity at low sucrose concentration but undergo strong conductivity suppression at elevated sucrose levels. Non-electrolytic systems remain consistently resistive regardless of sucrose content. These patterns are fully consistent with established principles of ionic conduction and solution dynamics.

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3.2. Influence of Sucrose and Ionic Composition on Solution Conductivity

The findings of this study indicate that sugar plays a significant role in altering the electrical conductivity of a solution. As a non-electrolyte, sucrose dissolves in water without undergoing ionization, meaning it remains entirely in molecular form and does not produce charged species capable of carrying electric current. Consequently, the presence of sugar suppresses the conductive ability of a solution, particularly under conditions involving strong electrical input.[16]

The conductivity of both electrolyte and non-electrolyte systems is governed by the number and concentration of ions present. Introducing additional solvent—such as a sugar solution—reduces ionic concentration and thereby lowers the overall current. Conversely, the conductivity of a solution can be increased by raising its solute concentration or combining it with a more acidic medium. Materials with higher acidity generate greater amounts of hydrogen ions, resulting in stronger ionization and enhanced electrical conductivity.[22]

4. CONCLUSION

The results of this study demonstrate that the electrical current produced by the tested mixtures is strongly dependent on their ionic composition and on the physicochemical changes induced by sucrose addition. In electrolyte systems such as salt solution, vinegar, and lime extract, low sucrose concentrations yield high current values due to the abundant presence of mobile ions. However, increasing sucrose content progressively reduces current strength, reflecting a combined effect of ion dilution, decreased dielectric constant, and reduced ionic mobility caused by viscosity enhancement. The salt solution exhibits this behavior most prominently, with current decreasing sharply as sucrose mass increases.

In contrast, non-electrolytic mixtures-namely sucrose solution and 70% alcohol-show consistently low current values across all concentrations, confirming the absence of significant ion populations and the inability of these media to support ionic conduction. The coffee system displays a slight non-monotonic response at moderate sucrose levels, likely arising from temporary enhancement of soluble ionizable constituents before conductivity declines at higher sucrose content.

Overall, the findings verify that sucrose acts as a non-dissociating solute that suppresses electrical conductivity in proportion to its concentration. The variations in current among different solution types arise from their intrinsic electrolytic behavior, dielectric characteristics, and ion-transport properties. These observations align with established electrolyte theory and reinforce the fundamental distinction between electrolyte and non-electrolyte systems.

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REFERENCES

1. Wilhelm E (**2022**) Solutions, in Particular Dilute Solutions of Nonelectrolytes: A Review. J Solution Chem 51, 626–710.
2. Zavitsas AA (**2022**) Properties of aqueous solutions. A treatise against osmotic and activity coefficients. J Mol Liq 348, 118410.
3. Munawwarah, Anwar M, Alimin (**2024**) Interactive E-Book Colligative Properties of Solutions: Connecting Science and Society in Chemistry Learning. Jurnal Penelitian Pendidikan IPA 10, 9208–9215.
4. Analita RN, Bakti I, Nugraheni PW, Noviyanti E (**2023**) The learners' conceptual understanding: Literature review of vapor-pressure lowering and boiling-point elevation. Journal of Education and Learning (EduLearn) 17, 641–651.
5. Rahmawati A, Kamaludin A (**2023**) Development of Motion Graphic Video for Electrolyte and Non-Electrolyte Solutions to Increase Senior High School Students' Interest in Learning. Jurnal Penelitian Pendidikan IPA 9, 1753–1764.
6. Thabiea ; Dewi AM, Haryani S (**2022**) Development of Three-Tier Test Instruments Based on Scientific Literacy in Electrolyte and Non-Electrolyte Solution Topics. Thabiea : Journal of Natural Science Teaching 5, 1–16.
7. Roling B, Kettner J, Miß V (**2022**) Classifying Electrolyte Solutions by Comparing Charge and Mass Transport. ENERGY & ENVIRONMENTAL MATERIALS 5, 6–9.
8. Gaohua L, Miao X, Dou L (**2021**) Crosstalk of physiological pH and chemical pKa under the umbrella of physiologically based pharmacokinetic modeling of drug absorption, distribution, metabolism, excretion, and toxicity. Expert Opin Drug Metab Toxicol 17, 1103–1124.
9. MIZUHATA M (**2022**) Electrical Conductivity Measurement of Electrolyte Solution. Electrochemistry 90, 22–66111.
10. Blazquez S, Abascal JLF, Lagerweij J, Habibi P, Dey P, Vlugt TJH, Moultos OA, Vega C (**2023**) Computation of Electrical Conductivities of Aqueous Electrolyte Solutions: Two Surfaces, One Property. J Chem Theory Comput 19, 5380–5393.
11. Vasheghani Farahani F, Amini MH, Ahmadi SH, Zakaria SA (**2021**) Investigation of layered double hydroxide/carbon dot nanocomposite on removal efficiency of Pb2+ from aqueous solution. J Mol Liq 338, 116774.
12. Torrik A, Zaerin S, Zarif M (**2022**) Doxorubicin and Imatinib co-drug delivery using non-covalently functionalized carbon nanotube: Molecular dynamics study. J Mol Liq 362, 119789.
13. Torrik A, Zaerin S, Zarif M (**2022**) Doxorubicin and Imatinib co-drug delivery using non-covalently functionalized carbon nanotube: Molecular dynamics study. J Mol Liq 362, 119789.
14. Pucholobek G, de Andrade CK, Rigobello ES, Wielewski P, de Toledo V de AA, Quináia SP (**2022**) Determination of the Ca, Mn, Mg and Fe in honey from multiple species of stingless bee produced in Brazil. Food Chem 367, 130652.
15. Ettarhouni ZO, Elhamassi A, Abughrin SE, ALaamin FS, Ismail S, Bhattarai A (**2025**) Investigation of the physical behavior of Magnesium Sulphate/Sucrose in pharmaceuticals at different temperatures. Carbohydrate Polymer Technologies and Applications 10, 100806.

e-ISSN : 2622-4968, p-ISSN : 2622-1349

16. Bakam Nguenouho OS, Chevalier A, Potelon B, Benedicto J, Quendo C (**2022**) Dielectric characterization and modelling of aqueous solutions involving sodium chloride and sucrose and application to the design of a bi-parameter RF-sensor. Sci Rep 12, 7209.
17. Ji F, Xia R, Tao H, Wei W, Mu X, Li D, Lu F (**2020**) Determination of organic acids in vinegar and related products by ion chromatography. Food Science 41, 239–44.
18. Bratthäll T (**2021**) Influence of divalent cations on extraction of organic acids in coffee. Umeå University, Sweden
19. El Fadel W, El Hantati S, Nour Z, Dinane A, Messnaoui B, Mounir A, Samaouali A, Arbaoui A (**2025**) Experimental and Modeling Study of the Thermodynamic Behavior and Solubility of the NH4NO3–D-Sucrose–Water Ternary System at 298.15 K. Processes 13, 3438.
20. Angeloni G, Masella P, Spadi A, Guerrini L, Corti F, Bellumori M, Calamai L, Innocenti M, Parenti A (**2023**) Using ground coffee particle size and distribution to remodel beverage properties. European Food Research and Technology 249, 1247–1256.
21. Karale RR, Kamble S, Alwaleedy S, Kabara KB, Narwade P, Al-Hamdani SM, Kumbharkhane AC, Sarode A V. (**2024**) Study of molecular interaction in aqueous sucrose in the GHz region using Time Domain Reflectometry (TDR). J Mol Struct 1307, 137973.
22. Shcherbakov V V., Artemkina YM, Akimova IA, Artemkina IM (**2021**) Dielectric Characteristics, Electrical Conductivity and Solvation of Ions in Electrolyte Solutions. Materials 14, 5617.

e-ISSN : 2622-4968, p-ISSN : 2622-1349