Austin Chemical Engineering

Open Access
Austin Publishing Group

Review Article

Exploring New Ideas: Personal Care and Challenges for Public Health and Covid-19 Crisis

Onyeocha VO[1*]; Onuchukwu AI[2]

[1]Department of Chemistry, Federal University of Technology, Owerri, 1526, Nigeria

[2]Department of Chemistry, Chukwuemeka Odumegwu Ojukwu University, Uli Campus Anambra, 431124, Nigeria

***Corresponding author:** Veronica Onyeocha
Department of Chemistry, Federal University of Technology, Owerri, 1526, Nigeria.
Email: ogechivera.nwagwu@gmail.com

Received: July 09, 2023
Accepted: July 11, 2023
Published: July 18, 2023

Abstract

Background: Public health is the science of preventing disease in the environment from afflicting the human population thereby prolonging life. This is achieved by promoting health care through organized efforts and informed choices amongst individuals or groups, such as society, organizations, public and private communities. A good approach reviews the health of the population and identifies the envisaged threats within the environment. The study on health takes into cognizance the physical, psychological and social well-being of the populace in a place under suspect.

Methods: Experts in environmental health examine the interactions of the people with the environment by assessing the ways these interactions affect the physical well-being and vulnerability to disease. Factors such as air pollution, improper waste management, dangerous chemicals, climate change effects, natural disaster, etc., may imbue public health issues in the community. Industries with poor manufacturing process and inappropriate waste management practices may adversely affect the natural habitat.

Consideration: The Covid-19 pandemic affected the European communities. This pandemic caused twofold crisis, namely: (i) Threat to Public Health (ii) Economic Meltdown. Since the beginning of the pandemic, communities, countries and organizations (such as World Health Organization and member states of United Nations) adopted measures to protect public health in terms of protocols. There is the introduction of internal border controls within the European Union (EU) to stem the Covid-19 spread. Other activities adopted were aimed at promoting trade policies and anti-dumping pacts to protect European industries that gave rise to international trade distortions. A company, Oxaquim, European manufacturer of oxalic acid ensures cleaner and greener environment in its process facility in the supply of oxalic acid to the EU. Oxalic acid is used to purify rare-earth elements for the manufacturing of electric engines for electric cars, microprocessors and windmill. A much better method however, could be used to establish efficient disposal of waste products from production plants. Also, the use of Ethylenediaminetetraacetic Acid (EDTA) may be reassessed to determine its safety as a sequestering agent, for food industry etc. EDTA is used for incidents of lead poisoning. EDTA is added to stored blood in blood banks as anticoagulant to bind Ca^{2+} (calcium ion). EDTA is used in detergents as a builder. EDTA is not biodegradable in the environment. Succinic acid is also considered.

Results: Onyeocha V. O. et al. illustrated the use of binary immiscible solvent in the recovery of oxalic acid, succinic acid and EDTA from effluents and contaminants. This report is another attempt to uphold the cleaner and greener environment.

Citation: Onyeocha VO, Onuchukwu AI. Exploring New Ideas: Personal Care and Challenges for Public Health and Covid-19 Crisis. Austin Chem Eng. 2023; 10(2): 1098.

Conclusion: This work introduces new ideas towards the sustainability of public health and mitigates insidious issues in the environment towards the prevention of any adverse effects on humans so that people can spend more viable years in good health.

Keywords: Public health; Environment; Threats; Organized efforts; Informed choices; Binary immiscible solvent; Oxalic acid; Succinic acid; Ethylenediaminetetraacetic acid

Introduction

Public health by [en.m.wikipedia.org], is healthcare for the prevention of disease in the environment in order to promote and prolong healthy life. It is an interdisciplinary discipline. Public health exercise is carried out through the monitoring of health indicators like life expectancy, etc., and through the promotion of healthy behaviors. Practices such as hand washing, use of vaccines, promotion of improved air quality, are instruments of public health. As recorded in [www.who.int], the circumstances and environment surrounding the people determine the health of such people. These determinants of health include the social and economic environment like good support from families, friends and communities; the physical environment like healthy workplaces; genetics; access to health services, etc. Analyzing the determinants of health of a population and the threats emanating from the interactions within the environment forms the basis for public health. Health is the state of complete emotional and physical well-being. It is the state of physical, mental and social well-being. It encompasses more than the absence of disease or infirmity. Good health helps people to live a full viable life. Healthcare is created to lead people maintain the optimal state of health [www.medicalnewstoday.com]. Exploring new ideas on public health helps to fight the biggest killers of humans. It has a preventative nature [www.bcu.ac.uk]. There is public health law that oversees the authority of the government at all levels to uphold public health within the limits and norms of the society [en.m.wikipedia.org]. This is the trust of good public health in our world.

The public could be as small as a handful of people or as large as a village or the whole city; in the case of a global epidemic, it could cover many continents [en.m.wikipedia.org]. The global health factor is the type that causes the deterioration of the earth's biosphere and climate change [www.euro.who.int]. The European's health is affected by factors such as lack of access to safe water, sanitation, air pollution, improper waste management, contaminated sites, exposure of dangerous chemicals, climate change, natural disaster, diseases caused by microbes, lack of access to health care, infrastructure issues and global environmental degradation [www.euro.who.int]. The European Economic Community (EEC) directive provides the measures used to checkmate these factors of public health [link.springer.com].

Environmental factors have influence on health. The factors are both natural and human-caused events [online.regiscollege.edu]. Air pollution is one of the major causes of premature death and disease. Fine Suspended Particulate Matter (SPM) causes the most substantial health problems [www.eea.europa.eu]. Air pollution is the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that changes the natural characteristics of the atmosphere. These pollutants include particulate matter, carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, etc. These cause respiratory diseases and other pulmonary associated diseases. They are sources of morbidity and mortality. Air pollution poses threat to health as well as climate change. The WHO data shows that about 99% of the global population breath air that exceeds WHO guideline limits that contains high levels of pollutants [www.who.int].

Corona virus disease 2019 (COVID-19) is a contagious disease caused by a virus, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [en.m.wikipedia.org]. The first registered case was captured in Wuhan, China, in December 2019. The disease spread worldwide, leading to the ongoing COVID-19 pandemic. COVID-19 transmits when people breathe in air contaminated by small droplets of airborne particles containing the virus. The risk of breathing the virus contaminated air is highest when people are in close proximity. Transmission occurs also when a person is splashed with contaminated fluids in the eyes, nose or mouth but rarely through contaminated surfaces [en.m.wikipedia.org, www.who.int]. Guided mitigation methods which are the products of organized efforts and informed choices have resulted to tame/stop the spread of the disease. Many COVID-19 testing methods are developed to diagnose the disease; vaccines are approved and distributed in countries. Preventive measures such as physical or social distancing, quarantining, ventilation of indoor spaces, covering coughs and sneezes, hand washing and keeping unwashed hands away from the face, are upheld and enforced. The use of face masks or coverings was recommended in public settings to reduce/stop the risk of transmission [en.m.wikipedia.org].

Air pollution causes health problems and raises the chances of death from COVID-19 infection [www.hsph.harvard.edu]. There is the established association between long term exposures to air pollution with about 11% increase in mortality from COVID-19 infection [www.hsph.harvard.edu]. The coronavirus pandemic affected the European societies [www.tandfonline.com]. The crisis poses threats to the social integration and cohesion of the societies. The pandemic provoked health threats and economic turmoil. In order to curb the spread of the disease, the European Council (EC) adopted coordinated approach for safe movement. There have been travel restrictions within the EU. Traveler's EU digital COVID certificate is invoked [www.consilium.europa.eu].

On the issue of public health, experts in the environmental health study how people associate with the world around them [online.regiscollege.edu]. The manners in which these interactions affect the physical fitness, proneness to disease and other aspects of human wellness are monitored. Some of the factors that are considered are: chemical safety, air pollution, climate change and natural disaster, diseases caused by microbes, lack of access to health care, infrastructure issues, poor water quality, global environmental issues, etc. Through conscious efforts on environmental health, health workers have improved personal wellness for individuals, families and communities. The increased awareness on public health leads to reduced exposure to disease and toxic pollutants [online.regiscollege.edu].

Industries with poor manufacturing conditions and poor waste disposal poison the natural world and affect the physical well-being of the communities [online.regiscollege.edu]. Industry is the production of economic good or service within the economy [en.m.wikipedia.org]. It is the backbone of the European economy. There are the service, manufacturing, and agricultural sectors. The digital and green transformations of EU industries are emphasized. Actions are taken to maintain European industries' global competitiveness to reach climate-neutrality [ec.europa.eu]. There are trade defence instruments such as the anti-dumping or subsidy duties to protect European manufacturing against international trade distortions [trade.ec.europa.eu]. Oxaquim is the leading manufacturer of oxalic acid in Europe [oxaquim.com]. Oxaquim ensures the supply of oxalic acid to the European Union while ensuring the cleaner and greener world and economy. Measures should be enforced for the management of the waste products from the production plants that are involved. Oxalic acid is used by consumers, in articles, by professional workers, in formulation or re-packing, at industrial sites and in manufacturing [echa.europa.eu]. Oxalic acid is a strategic component for emerging sectors. The commitment to sustainability and the environment makes Oxaquim the efficient manufacturer of oxalic acid in the world [trade.ec.europa.eu]. Succinic acid is used by consumers, by professional workers, in formulation or re-packing, at industrial sites and in manufacturing [echa.europa.eu]. The importance of ethylenediaminetetraacetic acid (EDTA) touches all aspects of life [www.m.wikipedia.org]. Questions have been raised to consider EDTA as a persistent organic pollutant. The continued existence of EDTA poses serious issues in the environment. The versatile nature of EDTA, succinic acid and oxalic acid in the industry, agriculture, and all aspects of life lead to the analyses for the green and cleaner environment [www.analytice.com/en/analysis-of-ethylenediaminetetraacetic-acid] [1-3].

This paper illustrates the use of binary immiscible solvent, as applied in Onyeocha et. al [1,2], in the extraction, purification, beneficiation, etc. of oxalic acid, succinic acid and ethylenediaminetetraacetic acid (the solute), from contaminants, from effluents and from any matrix in which the solute is embedded. The use of binary immiscible solvent involves the principle of partition coefficient.

Binary immiscible solvent: Binary liquid mixtures are liquids that are composed of two different molecular compounds. The example is oil and water [echa.europa.eu]. A binary immiscible solvent is a solvent that is formed from two liquids that are immiscible. Miscibility is the ability of a liquid to mix and form a homogeneous solution that is soluble in any proportion. Immiscibility is used to describe the liquids that cannot mix to form a homogeneous solution. Immiscible solvents will separate into layers [delloyd.50megs.com]. If two liquids form a layer, they are immiscible. They most common determination of miscibility is by visual evaluation [www.sigmaaldrich.com]. Components of a binary immiscible solvent will separate from each other. The less dense liquid will rise to the top and the more dense liquid will sink below. Oil-water, carbon tetrachloride-water, etc. are immiscible liquids in contrast to alcohol-water which is miscible [www.quora.com].

Liquid-liquid extraction: This is the method used to separate molecules and materials based on their relative solubility in two immiscible liquids (binary immiscible solvent). Usually, the liquids are water and an organic solvent. There is the net transfer of one or more species from one liquid to another liquid, from the aqueous to the organic layer [en.m.wikipedia.org]. The transfer is driven by the partition coefficient gradient, (k_D) that is associated with the binary solutions [1-3]. This involves the separation of substance from a mixture by preferentially dissolving that substance in a suitable solvent. A soluble compound is separated from an insoluble compound or a compound matrix or crystal [en.m.wikipedia.org]. The extracting liquid used for liquid-liquid extraction must be selective for the solute that is being extracted. The liquid containing the raffinate must be of low solubility. Generally, the solvent should be low cost, have good recoverability, non-corrosive and non-inflammable [www.thermopedia.com]. Liquid-liquid extraction is a countercurrent separation process for isolating the constituents of a liquid mixture. The solute being extracted must have high affinity for the extracting liquid. The transfer of the solute from one liquid phase to another is an equilibrium relationship. It involves the proper selection of solvent [e5-10-04-07.pdf].

Partition coefficient: Partition coefficient describes how a substance distributes itself between two phases. It is defined as the ratio of the concentration of a substance in one medium to the concentration of the substance in the other medium, when the system is at equilibrium [www.sciencedirec.com]. Consider a binary immiscible solvent formed from liquids 'A' and 'B', at constant temperature and pressure, in a separating funnel. The solute 'X' is added also to the separating funnel. The separating funnel is shaken so that the solute X is allowed to dissolve in both A and B. The resulting two immiscible solutions are allowed to settle until equilibrium is reached. According to Nernst's distribution law, when a solute that is soluble in each of the binary immiscible solvent is introduced into the solvent, the solute distributes itself between the two liquids in such a way that the ratio of its concentration in the two liquids is constant. This constant is known as partition coefficient [study.com, [1-3].

Partition coefficient, k_D, is given as:

$$k_D = \frac{\text{concentration of X in liquid A}}{\text{concentration of X in liquid B}} \qquad (1)$$

According to Onyeocha et. al., the use of partition coefficient technique to predict mode of extraction has long been in practice in solvent/solute extraction. Partition coefficient is a beneficiation parameter, as in thermodynamics, to checkmate the efficiency of solute extraction in binary immiscible solvent. It is in accordance with the predictive parameters such as, Enthalpy, H, and Gibb's Free Energy, G. "k_D" is the driving force for solute extraction with binary immiscible solvent.

Background of the study: This paper discusses issues on public health with regards to promoting healthy life style. A survey of the measures that are taken to control the spread of COVID-19 that is ravaging most of the populace of the world is also addressed. The discussion equally highlights the cost-effective measure that could be taken by industries that deal with oxalic acid, succinic acid and ethylenediaminetetraacetic acid.

Statement of the problem: Public health issue is a consistent issue of humanity. The interaction of man with the environment gives birth to actions which are harmful to health. Although some of the health-inflicting actions on mankind are of natural disasters, it behooves on man (professionals) to underscore the measures to control the negative health inflicting actions, for the healthy viable lives of the populace and the environment.

Objective of the study: The write-up reviews the case of COVID-19 pandemic, its mode of transmission and the ways the spread of the disease is controlled. Also, three cases of the industries are enlisted:

- The production and handling of oxalic acid
- The case of succinic acid
- The case of EDTA

The use of binary immiscible solvent is illustrated as the method that could be used to stop the pollution of the environment with these potent substances that could be harmful to humankind if not well handled.

Justification of the study: The COVID-19 pandemic affected the cold countries of Europe more than African countries. Since the beginning of the pandemic, researches are conducted with findings which help in the control of the disease. The organized activities of mankind which have led to the development of industries are not left out in the consideration of the issues of public health. A substance like oxalic acid under exposure causes headache, dizziness, nausea and vomiting, convulsions, coma and even death. Prolonged contact causes skin rash, pain, redness, blisters and slow healing ulcers/severe gastroenteritis and vomiting. [www.nj.gov, www.ontariobee.com, www.healthline.com] Succinic acid when inhaled, ingested or brought to contact causes skin irritation, burns, gastrointestinal irritation with nausea, vomiting and diarrhea, respiratory tract irritation. [fscimage.fishersci.com] EDTA causes abdominal cramps, nausea, vomiting, diarrhea, headache, low blood pressure, skin problem and fever, kidney damage, dangerously low calcium levels and death. [www.webmd.com]

Scope of study: The write-up considers new ideas, personal care and challenges for public health and COVID-19 crisis in Europe. The accepted result could be extended to any part of the world. The issues of health, the activities of mankind, the effect and control of the use of substances like oxalic acid, succinic acid, EDTA, are the same on humankind.

Methods: The determinants of the health of the society are reviewed. The threats the environment poses to the public health are analyzed. The results of the research for the control of the ramification of the use of oxalic acid, succinic acid and ethylenediaminetetraacetic acid are given in the tables and figures below.

Analysis: From Nernst distribution law, when a substance distributes itself between two solvents, at equilibrium, the ratio of the activities of the substance in the phases is constant at the given temperature and pressure. [1-5] This law shows the dissolution of the solute in the binary immiscible solvent represented as liquid A and liquid B (Liquid A-B), at constant temperature and pressure.

Mathematically, Nernst distribution law states that:

$$\text{In}\frac{a_B}{a_A}=\text{constant}=k_D \qquad (2)$$

When the solute (such as oxalic acid, succinic acid, or EDTA) undergoes a chemical reaction like in the case of dimerization reaction, anhydride formation or ionization reaction, as defined by Rastogi et. al [5], the partition law is defined for the case of dimerization of the solute by the equation:

$$\frac{C_X^A}{C_X^{*B}}=K_D+2k_D^2KC_X^{*B} \qquad (3)$$

From equation (3), a plot of $\frac{C_X^A}{C_X^{*B}}$ vs C_X^{*B} is a straight line with intercept k_D and slope equal to $2k_D^2K$. This enables the calculation of the dimerization constant, K.

Furthermore, when the solute undergoes ionization in the solvent, the equation (4) below is used:

$$\frac{C_X^A}{C_X^B}=K_D+(Kk_D)^{1/2}(C_X^{*B}) \qquad (4)$$

A plot of $\frac{C_X^A}{C_X^{*B}}$ vs $\frac{1}{(C_X^{*B})^{1/2}}$ gives a straight line with intercept k_D, and a slope equal to $(Kk_D)^{1/2}$. The ionization constant

$K \equiv a$ is calculated

When both dimerization and ionization reactions are taking place in solvents A and B respectively, then equation (5) is used [5]:

$$\frac{C_X^A}{C_X^{*B}}=K_D(1-a)+2k_D^2K(1-a)^2C_X^{*B} \qquad (5)$$

The equations (3), (4) and (5) are applied in all the tables [6] and figures below to calculate the partition coefficient, dimerization constant and ionization constant for the analyses of the binary solvents and the efficiency of the partition coefficient technique for the respective solutes in the required medium.

Table 1: Data for the partition coefficient (k_D) for oxalic acid in carbon tetrachloride-water at 30°C and atmospheric pressure, equation (3).

Mass of oxalic acid (g)	Concentration in carbon tetrachloride (A) (C_x^A) (mole/litre)	Concentration in water (B) (C_{x*}^B) (mole/litre)	$\frac{C_X^A}{C_X^{*B}}$(k_D)
0.4	0.0075	0.1475	0.0508
0.6	0.0075	0.2225	0.0337
0.8	0.0063	0.2888	0.0218
1.0	0.0050	0.3650	0.0137

Table 2: Data for the partition coefficient of oxalic acid in carbon tetrachloride-water at 30⁰C and atmospheric pressure for the plot: $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x*}^B)^{1/2}$, equation (4).

$\frac{C_X^A}{C_X^{*B}}$	$1/\sqrt{C_{x*}^B}$ (mole/litre)$^{-1/2}$
0.0508	2.6035
0.0337	2.1199
0.0218	1.8608
0.0137	1.6551

Table 3: Data for the partition coefficient of oxalic acid in carbon tetrachloride-water at 30⁰C and atmospheric pressure for the plot $\frac{C_X^A}{C_X^{*B}}$ (1-α) vs C_{x*}^B(1-α), equation (5).

$\frac{C_X^A}{C_X^{*B}}$	$\frac{C_X^A}{C_X^{*B}}$ (1-α)	C_{x*}^B (mole/litre)	C_{x*}^B(1-α)(mole/litre)
0.0508	0.0493	0.1475	0.1430
0.0337	0.0327	0.2225	0.2158
0.0218	0.0211	0.2888	0.2800
0.0137	0.0133	0.3650	0.3539

Table 4: Data for the partition coefficient (k_D) for oxalic acid in the binary solvent: diethyl ether-water at 30^{0}C and atmospheric pressure for equation (3).

Mass of oxalic acid (g)	Concentration in diethyl ether (C_x^A) (mole/litre)	Concentration in water (C_x^{*B}) (mole/litre)	$\frac{C_X^A}{C_X^{*B}}$ (k_D)
0.4	0.0050	0.1400	0.0357
0.6	0.0050	0.1925	0.0260
0.8	0.0125	0.3125	0.0400
1.0	0.0175	0.3350	0.0522

Table 5: Data for the partition coefficient of oxalic acid in diethyl ether-water at 30^{0}C and atmospheric pressure, for the plot $\frac{C_X^A}{C_X^{*B}}$ vs 1/(C_{x*}^B)$^{1/2}$ from equation (4).

$\frac{C_X^A}{C_X^{*B}}$	1/√ C_{x*}^B (mole/litre)$^{-1/2}$
0.0357	2.6724
0.0260	2.2795
0.0400	1.7889
0.0522	1.7277

Table 6: Data for the partition coefficient of oxalic acid in diethyl ether-water at 30^{0}C and atmospheric pressure for the plot of equation (5).

$\frac{C_X^A}{C_X^{*B}}$	$\frac{C_X^A}{C_X^{*B}}$(1-α)	C_{x*}^B (mole/litre)	C_{x*}^B(1-α) (mole/litre)
0.0357	0.0356	0.1400	0.1395
0.0260	0.0259	0.1925	0.1918
0.0400	0.0399	0.3125	0.3114
0.0522	0.0520	0.3350	0.3338

Table 7: Data for the partition coefficient (k_D) for oxalic acid in n-hexane-water at 30^{0}C and atmospheric pressure for equation (3).

Mass of oxalic acid (g)	Concentration in n-hexane (C_x^A) (mole/litre)	Concentration in water (C_x^{*B}) (mole/litre)	$\frac{C_X^A}{C_X^{*B}}$ (k_D)
0.4	0.0075	0.2300	0.0326
0.6	0.0025	0.1650	0.0152
0.8	0.0050	0.2975	0.0168
1.0	0.0050	0.3675	0.0136

Table 8: Data for the partition coefficient of oxalic acid in n-hexane-water at 30^{0}C and atmospheric pressure for the plot $\frac{C_X^A}{C_X^{*B}}$ vs 1/(C_{x*}^B)$^{1/2}$, equation (4).

$\frac{C_X^A}{C_X^{*B}}$	1/√ C_{x*}^B (mole/litre)$^{-1/2}$
0.0326	2.0851
0.0152	2.4618
0.0168	1.8335
0.0136	1.6496

Table 9: Data for the partition coefficient of oxalic acid in n-hexane-water at 30^{0}C and atmospheric pressure for the plot: $\frac{C_X^A}{C_X^{*B}}$(1- α) vs C_{x*}^B(1- α), equation (5).

$\frac{C_X^A}{C_X^{*B}}$	$\frac{C_X^A}{C_X^{*B}}$(1- α)	C_{x*}^B (mole/litre)	C_{x*}^B(1- α) (mole/litre)
0.0326	0.0325	0.2300	0.2296
0.0152	0.0152	0.1650	0.1647
0.0168	0.0168	0.2975	0.2969
0.0136	0.0136	0.3675	0.3668

Table 11: Data for the partition coefficient (k_D) for succinic acid in the binary solvent of carbon tetrachloride-water at 30°C and atmospheric pressure, equation (3).

Mass of succinic acid (g)	Concentration in carbon tetrachloride (C_x^A) (mole/litre)	Concentration in water (C_{x*}^B) (mole/litre)	$\frac{C_X^A}{C_X^{*B}}$(k_D)
0.4	0.0075	0.1775	0.0423
0.6	0.0025	0.2950	0.0085
0.8	0.0025	0.4550	0.0055
1.0	0.0050	0..4050	0.0123

Table 12: Data for the partition coefficient of succinic acid in carbon tetrachloride-water at 30^{0}C and atmospheric pressure for the plot $\frac{C_X^A}{C_X^{*B}}$ vs 1/(C_{x*}^B)$^{1/2}$ equation (4).

$\frac{C_X^A}{C_X^{*B}}$	1/√ C_{x*}^B (mole/litre)$^{-1/2}$
0.0423	2.3736
0.0085	1.8413
0.0055	1.4826
0.0123	1.5713

Table 13: Data for the partition coefficient of succinic acid in carbon tetrachloride-water at 30^{0}C and atmospheric pressure for the plot k_D(1-α) vs C_{x*}^B(1-α) equation (5).

$\frac{C_X^A}{C_X^{*B}}$	$\frac{C_X^A}{C_X^{*B}}$ (1-α)	C_{x*}^B (mole/litre)	C_{x*}^B(1-α) (mole/litre)
0.0423	0.0411	0.1775	0.1725
0.0085	0.0083	0.2950	0.2866
0.0055	0.0053	0.4550	0.4421
0.0123	0.0120	0.4050	0.3935

Table 14: Data for the partition coefficient (k_D) for succinic acid in the binary solvent: diethyl ether-water at 30^{0}C and atmospheric pressure, for equation (3).

Mass of succinic acid (g)	Concentration in diethyl ether (C_x^A) (mole/litre)	Concentration in water (C_{x*}^B) (mole/litre)	$\frac{C_X^A}{C_X^{*B}}$ (k_D)
0.4	0.0075	0.1675	0.0448
0.6	0.0025	0.1800	0.0139
0.8	0.0095	0.3100	0.0306
1.0	0.0050	0.3950	0.0127

Table 15: Data for the partition coefficient of succinic acid in diethyl ether-water at 30^{0}C and atmospheric pressure, for the plot $\frac{C_X^A}{C_X^{*B}}$ vs 1/(C_{x*}^B)$^{1/2}$ for equation (4).

$\frac{C_X^A}{C_X^{*B}}$	1/√ C_{x*}^B (mole)$^{-1/2}$
0.0448	2.4432
0.0139	2.3568
0.0306	1.7960
0.0127	1.5911

Table 16: Data for the partition coefficient of succinic acid in diethyl ether-water at 30^{0}C and atmospheric pressure for the plot $\frac{C_X^A}{C_X^{*B}}$ (1-α) vs C_{x*}^B(1-α) equation (5).

$\frac{C_X^A}{C_X^{*B}}$	$\frac{C_X^A}{C_X^{*B}}$(1-α)	C_{x*}^B (mole/litre)	C_{x*}^B(1-α) (mole/litre)
0.0448	0.0433	0.1675	0.1619
0.0139	0.0134	0.1800	0.1740
0.0306	0.0296	0.3100	0.2997
0.0127	0.0123	0.3950	0.3819

Table 10: The partition coefficient, k_D, dimerization constant, K, and ionization constant, α, for oxalic acid in the binary immiscible solvents, carbon tetrachloride-water, diethyl ether-water and n-hexane-water respectively at 30^{0}C and atmospheric pressure.

Oxalic acid	Partition coefficient, k_D	Dimerization constant, K	Ionization constant, α	Association and ionization
Carbon tetrachloride-water	0.07383	-15.7092	0.0303	-16.6974
Diethyl ether-water	0.0173	144.0167	0.0035	144.98
n-hexane-water	0.02793	20.2798	0.0019	-20.296

Table 17: Data for the partition coefficient (k_D) for succinic acid in the binary solvent: n-hexane-water at 30⁰C and atmospheric pressure, for equation (3).

Mass of succinic acid (g)	Concentration in n-hexane (C_x^A) (mole/litre)	Concentration in water (C_x^{*B}) (mole/litre)	$\frac{C_x^A}{C_x^{*B}}$ (k_D)
0.4	0.0050	0.1900	0.0263
0.6	0.0025	0.2500	0.0100
0.8	0.0050	0.3175	0.0157
1.0	0.0325	0.4000	0.0813

Table 18: Data for the partition coefficient of succinic acid in n-hexane-water at 30⁰C and atmospheric pressure, for the plot $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x*}^B)^{1/2}$ for equation (4).

$\frac{C_X^A}{C_X^{*B}}$	$1/\sqrt{C_{x*}^B}$ (mole/litre)$^{-1/2}$
0.0263	2.2941
0.0100	2.0000
0.0157	1.7746
0.0813	1.5810

Table 19: Data for the partition coefficient of succinic acid in n-hexane-water at 30⁰C and atmospheric pressure, for the plot $\frac{C_X^A}{C_X^{*B}}(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$, equation (5).

$\frac{C_X^A}{C_X^{*B}}$	$\frac{C_X^A}{C_X^{*B}}(1-\alpha)$	C_{x*}^B (mole/litre)	$C_{x*}^B(1-\alpha)$ (mole/litre)
0.0263	0.0256	0.1900	0.1850
0.0100	0.0097	0.2500	0.2434
0.0157	0.0153	0.3175	0.3091
0.0813	0.0791	0.4000	0.3894

Table 20: Values for partition coefficient, k_D, dimerization constant, K, and ionization constant, α, for succinic acid in the binary immiscible solvents carbon tetrachloride-water, diethyl ether-water and n-hexane-water respectively at 30⁰C and atmospheric pressure.

Succinic acid	Partition coefficient k_D	Dimerization constant, K	Ionization constant, α	Association and ionization constant
Carbon tetrachloride-water	-0.0562	-18.5655	0.0284	-19.6457
Diethyl ether-water	0.0427	-18.1611	0.0332	-19.17
n-hexane-water	-0.0427	71.9491	0.0265	75.89

Table 21: Data for the partition coefficient (k_D) of EDTA in carbon tetrachloride-water at 30°C and atmospheric pressure for equation (3).

Mass of EDTA	Concentration in carbon tetrachloride (A) (C_x^A) (mole/litre)	Concentration in water (B) (C_x^{*B}) (mole/litre)	$\frac{C_x^A}{C_x^{*B}}$ (k_D)
0.4	0.0038	0.0038	1.0000
0.6	00038	0.0063	0.6032
0.8	0.0025	0.0025	1.0000
1.0	0.0025	0.0013	1.9231

Table 22: Data for the partition coefficient of EDTA in carbon tetrachloride-water at 30°C and atmospheric pressure for the plot: C_x^A/C_{x*}^B vs $1/(C_{x*}^B)^{1/2}$ equation (4).

C_x^A/C_{x*}^B	$1/\sqrt{C_{x*}^B}$ (mole/litre)$^{-1/2}$
1.0000	16.2338
0.6032	12.5945
1.0000	20.0000
1.9231	27.7008

Table 23: Data for the partition coefficient of EDTA in carbon tetrachloride-water at 30°C and atmospheric pressure for the plot $C_x^A/C_{x*}^B(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$ equation (5).

C_x^A/C_{x*}^B	$C_x^A/C_{x*}^B(1-\alpha)$	C_{x*}^B (mole/litre)	$C_{x*}^B(1-\alpha)$ (mole/litre)
1.0000	0.9851	0.0038	0.0037
0.6032	0.5942	0.0063	0.0062
1.0000	0.9851	0.0025	0.0025
1.9231	1.8944	0.0013	0.0013

Table 24: Data for the partition coefficient (k_D) for EDTA in the binary solvents: diethyl ether-water at 30°C and atmospheric pressure for equation (3).

Mass of EDTA (g)	Concentration in diethyl ether (C_x^A) (mole/litre)	Concentration in water (C_x^{*B}) (mole/litre)	$\frac{C_x^A}{C_x^{*B}}$(k_D)
0.4	0.0013	0.0025	0.5200
0.6	0.0038	0.0025	1.5200
0.8	0.0038	0.0038	1.0000
1.0	0.0050	0.0100	0.5000

Table 25: Data for the partition coefficient of EDTA in diethyl ether-water at 30°C and atmospheric pressure, for the plot C_x^A/C_{x*}^B vs $1/(C_{x*}^B)^{1/2}$ from equation (4).

C_x^A/C_{x*}^B	$1/\sqrt{C_{x*}^B}$ (mole/litre)$^{-1/2}$
0.5200	20.0000
1.5200	20.0000
1.0000	16.2338
0.50000	10.0000

Table 26: Data for the partition coefficient of EDTA in diethyl ether-water at 30°C and atmospheric pressure for the plot of equation (5).

C_x^A/C_{x*}^B	$C_x^A/C_{x*}^B(1-\alpha)$	C_{x*}^B (mole/litre)	$C_{x*}^B(1-\alpha)$ (mole/litre)
0.5200	0.4843	0.0025	0.0023
1.5200	1.4156	0.0025	0.0023
1.0000	0.9313	0.0038	0.0035
0.5000	0.4657	0.0100	0.0093

Table 27: Data for the partition coefficient (k_D) for EDTA in n-hexane-water at 30°C and atmospheric pressure for equation (3).

Mass of EDTA (g)	C_x^A/C_{x*}^B	C_{x*}^B (mole/litre)
0.4	0.6500	0.0020
0.6	0.2778	0.0018
0.8	0.5333	0.0015
1.0	0.7222	0.0018

Table 28: Data for the partition coefficient of EDTA in n-hexane-water at 30°C and atmospheric pressure for the plot C_x^A/C_{x*}^B vs $1/(C_{x*}^B)^{1/2}$ from equation (4).

C_x^A/C_{x*}^B	$1/\sqrt{C_{x*}^B}$ (mole/litre)$^{-1/2}$
0.6500	22.3714
0.2778	23.5849
0.5333	25.8398
0.7222	23.5849

Table 29: Data for the partition coefficient of EDTA in n-hexane-water at 30°C and atmospheric pressure for the plot: $C_x^A/C_{x*}^B(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$ equation (4).

C_x^A/C_{x*}^B	$C_x^A/C_{x*}^B(1-\alpha)$	C_{x*}^B (mole/litre)	$C_{x*}^B(1-\alpha)$ (mole/litre)
0.6500	0.6497	0.0020	0.0020
0.2778	0.2777	0.0018	0.0018
0.5333	0.5330	0.0015	0.0015
0.7222	0.7218	0.0018	0.0018

Table 30: The partition coefficient, k_D, dimerization constant, K, and ionization constant, α, for ethylenediaminetetraacetic acid (EDTA) in the binary immiscible solvents: carbon tetrachloride-water, diethyl ether-water and n-hexane-water respectively at 30°C and atmospheric pressure.

EDTA	Distribution coefficient k_D	Dimerization constant, K	Ionization constant α	Association & ionization constant
Carbon tetrachloride-water	1.92128	-30.7821	0.0149	-31.76
Diethylether-water	1.21856	-23.8972	0.0687	-27.62
n-hexane-water	0.20346	2329.7237	0.0005	-2337.0768

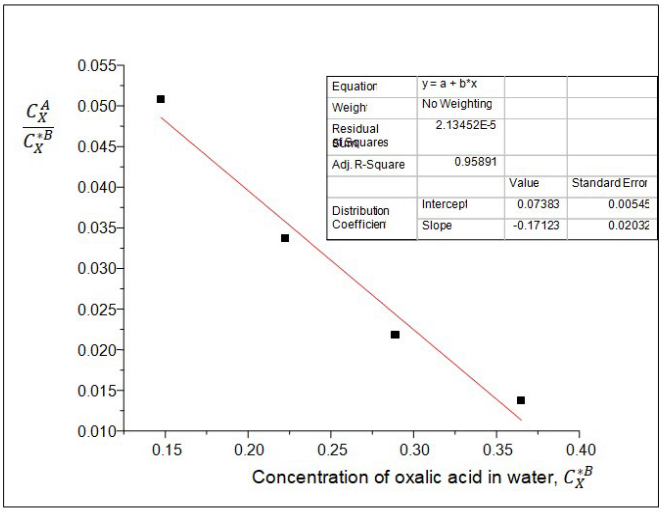

Figure 1: Plot for $\frac{C_X^A}{C_X^{*B}}$ vs $C_{x^*}{}^B$ at 30°C and atmospheric pressure for oxalic acid in carbon tetrachloride-water, from equation (3).

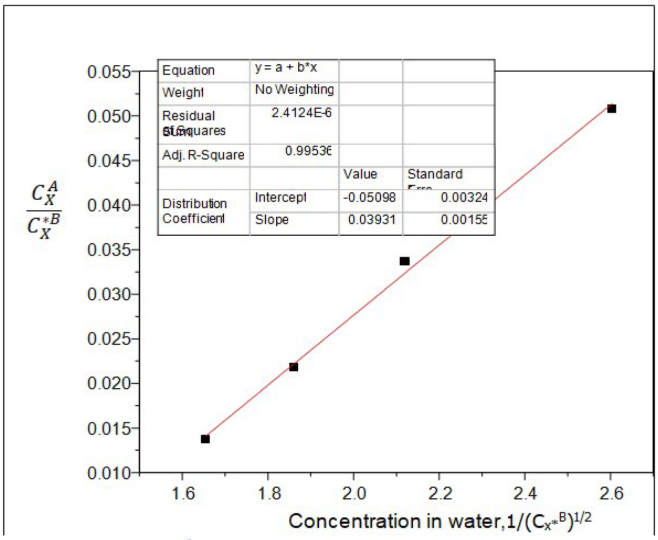

Figure 2: Plot of $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x^*}{}^B)^{1/2}$ for the ionization of oxalic acid in water of carbon tetrachloride-water at 30°C and atmospheric pressure from equation (4).

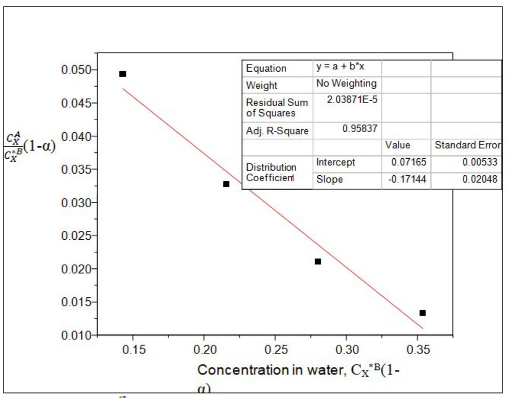

Figure 3: Plot for $\frac{C_X^A}{C_X^{*B}}(1-\alpha)$ vs $C_{x^*}{}^B(1-\alpha)$ for the association and ionization of oxalic acid in carbon tetrachloride-water at 30°C and atmospheric pressure, equation (5).

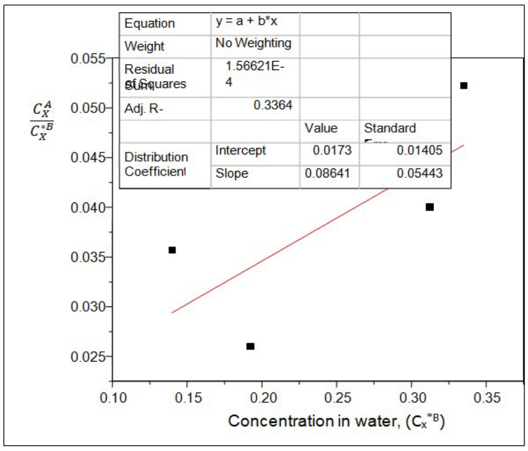

Figure 4: Plot for $\frac{C_X^A}{C_X^{*B}}$ vs $C_{x^*}{}^B$ for oxalic acid in diethyl ether-water at 30°C and atmospheric pressure, from equation (3).

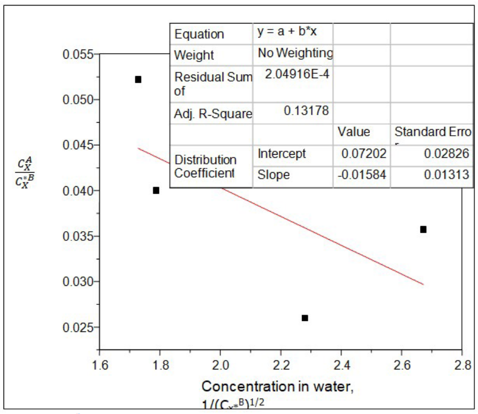

Figure 5: Plot for $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x^*}{}^B)^{1/2}$ for the ionization of oxalic acid in water of diethyl ether-water at 30°C and atmospheric pressure, from equation (4).

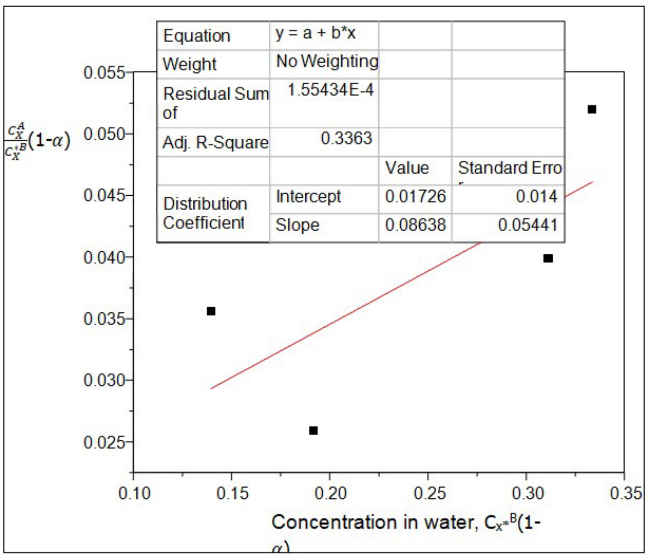

Figure 6: Plot for oxalic acid in diethyl ether-water at 30°C and atmospheric pressure for the plot $\frac{C_X^A}{C_X^{*B}}(1-\alpha)$ vs $C_{x^*}{}^B(1-\alpha)$, equation (5).

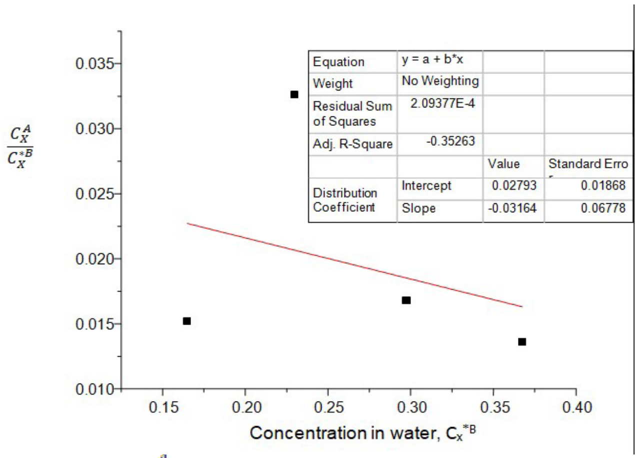

Figure 7: Plot of $\frac{C_X^A}{C_X^{*B}}$ against C_x^{*B} for oxalic acid in n-hexane-water at 30^{0}C and atmospheric pressure, equation (3).

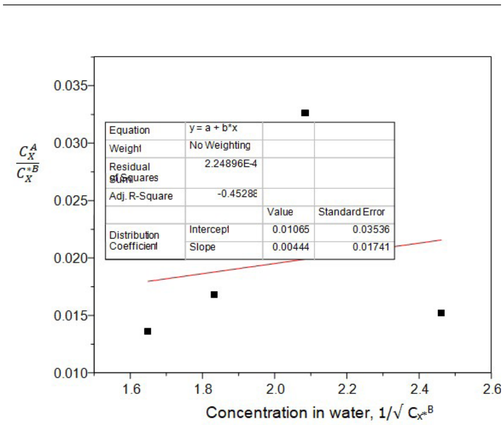

Figure 8: Plot for $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x^*}{}^{B})^{1/2}$ for oxalic acid in n-hexane-water at 30^{0}C and atmospheric pressure, equation (4).

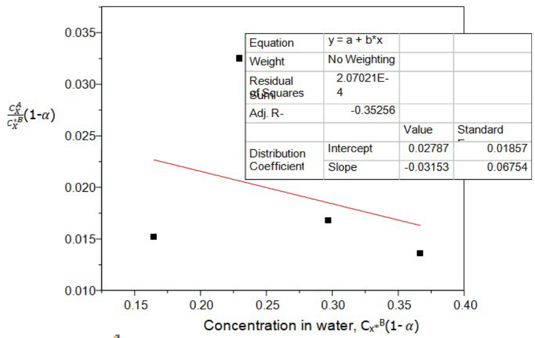

Figure 9: Plot for $\frac{C_X^A}{C_X^{*B}}(1-\alpha)$ vs $C_{x^*}{}^{B}(1-\alpha)$ for oxalic acid in n-hexane-water at 30^{0}C and atmospheric pressure, equation (5).

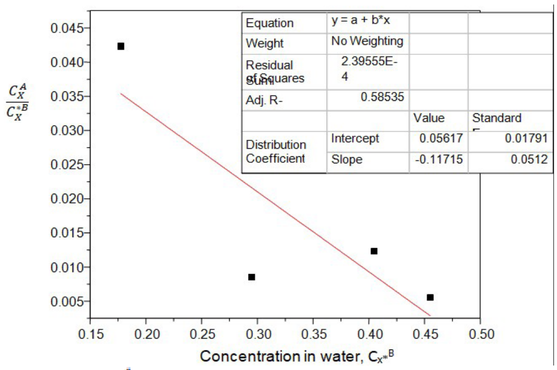

Figure 10: Plot of $\frac{C_X^A}{C_X^{*B}}$ vs $C_{x^*}{}^{B}$ for succinic acid in carbon tetrachloride-water at 30^{0}C and atmospheric pressure for equation (3).

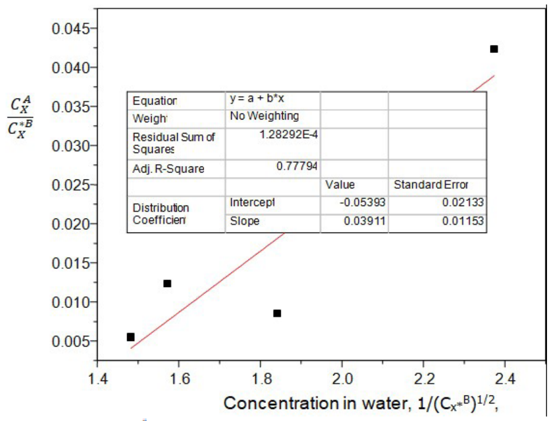

Figure 11: Plot of $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x^*}{}^{B})^{1/2}$ for the ionization of succinic acid in water of carbon tetrachloride-water at 30°C and atmospheric pressure for equation (4).

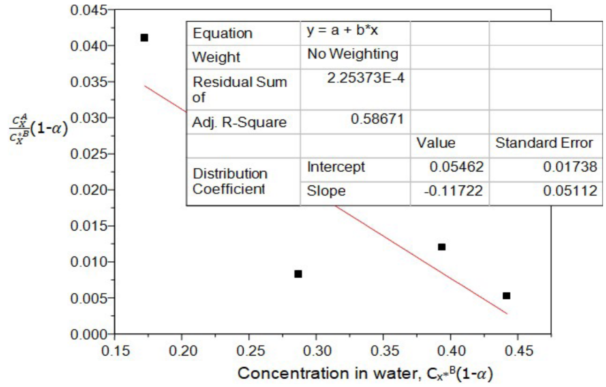

Figure 12: Plot for $\frac{C_X^A}{C_X^{*B}}(1-\alpha)$ vs $C_{x^*}{}^{B}(1-\alpha)$ for the association and ionization of succinic acid in both carbon tetrachloride and water of carbon tetrachloride-water system, at 30°C and atmospheric pressure for equation (5).

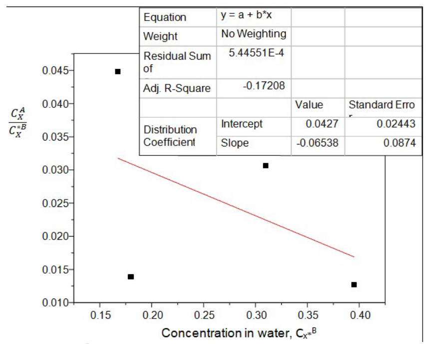

Figure 13: Plot for $\frac{C_X^A}{C_X^{*B}}$ vs $C_{x^*}{}^{B}$ for succinic acid in diethyl ether-water at 30°C and atmospheric pressure, for equation (3).

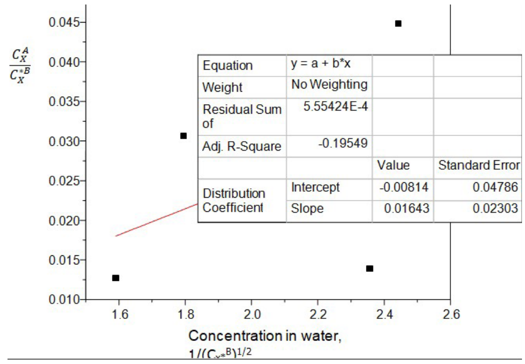

Figure 14: Plot for the partition coefficient of succinic acid in diethyl ether-water at 30^{0}C and atmospheric pressure, for the plot $\frac{C_X^A}{C_X^{*B}}$ vs $1/(C_{x^*}{}^{B})^{1/2}$, from equation (4).

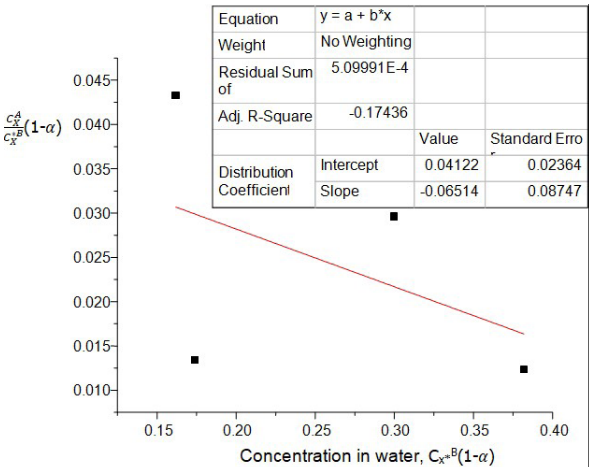

Figure 15: Plot for the partition coefficient of succinic acid in diethyl ether-water at 30⁰C and atmospheric pressure, for the plot $\frac{C_x^A}{C_{x^*}^B}(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$ from equation (5).

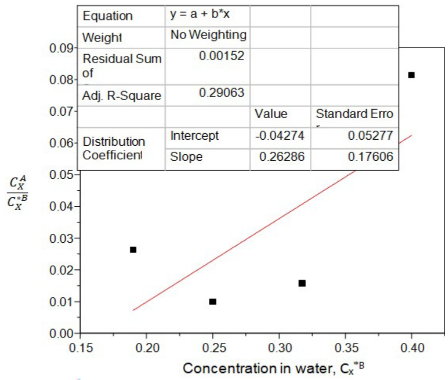

Figure 16: Plot $\frac{C_x^A}{C_x^{*B}}$ vs C_x^{*B} for succinic acid in n-hexane-water at 30⁰C and atmospheric pressure, for equation (3).

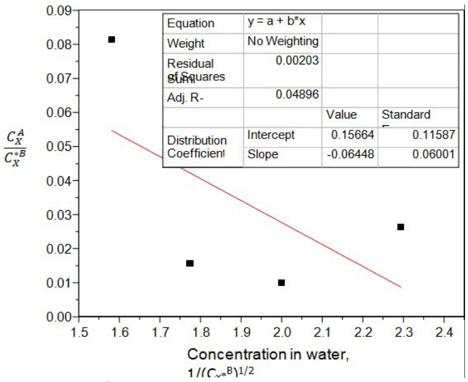

Figure 17: Plot for $\frac{C_x^A}{C_x^{*B}}$ vs $1/(C_{x*}^B)^{1/2}$ for succinic acid ionization in water of n-hexane-water at 30⁰C and atmospheric pressure using equation (4).

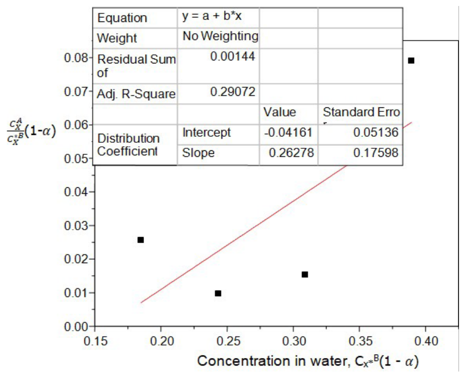

Figure 18: Plot for $\frac{C_x^A}{C_x^{*B}}(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$ for succinic acid in n-hexane-water at 30⁰C and atmospheric pressure, for equation (5).

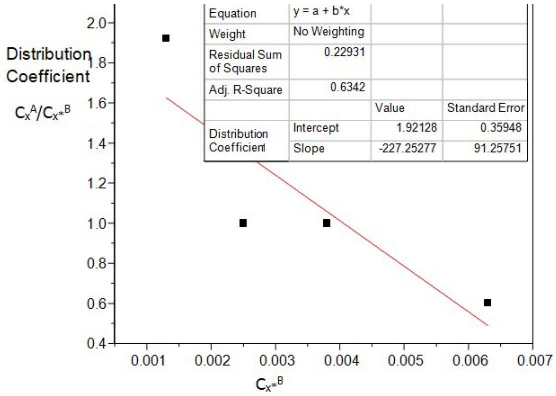

Figure 19: Plot for C_x^A/C_{x*}^B vs C_{x*}^B at 30°C and atmospheric pressure for EDTA in carbon tetrachloride-water, from equation (3).

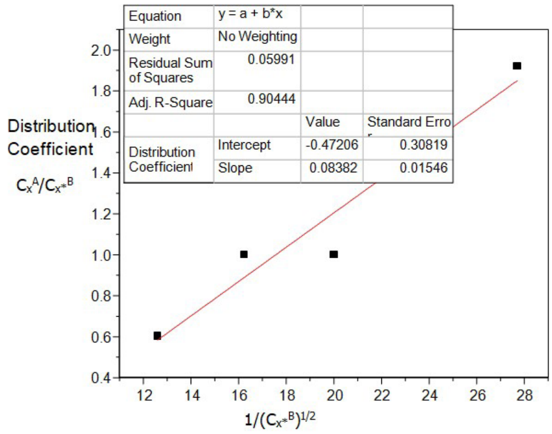

Figure 20: Plot of C_x^A/C_{x*}^B vs $1/(C_{x*}^B)^{1/2}$ for the ionization of EDTA acid in water of carbon tetrachloride-water at 30°C and atmospheric pressure from equation (4).

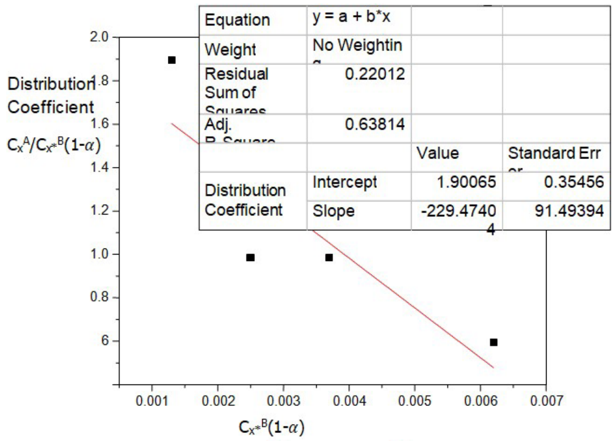

Figure 21: Plot for $C_x^A/C_{x*}^B(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$ for the association and ionization of EDTA in carbon tetrachloride-water at 30°C and atmospheric pressure, for equation (4).

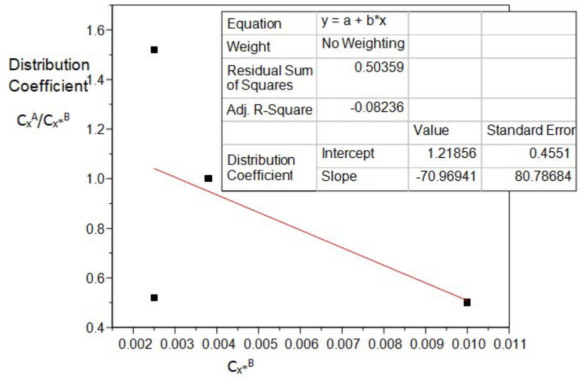

Figure 22: Plot for C_x^A/C_{x*}^B vs C_{x*}^B for EDTA in diethyl ether-water at 30°C and atmospheric pressure, from equation (3).

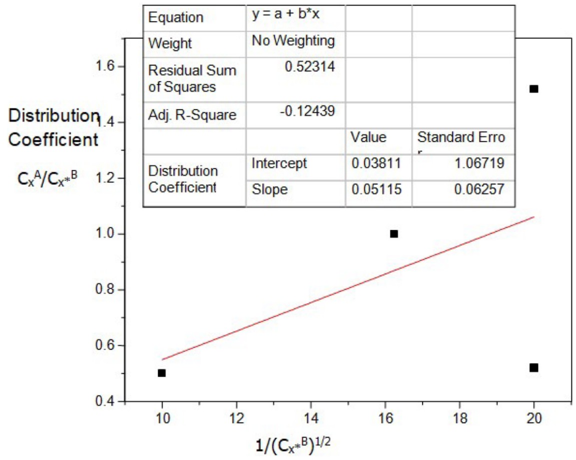

Figure 23: Plot for C_x^A/C_{x*}^B vs $1/(C_{x*}^B)^{1/2}$ for the ionization of EDTA in water of diethyl ether-water at 30°C and atmospheric pressure, from equation (4).

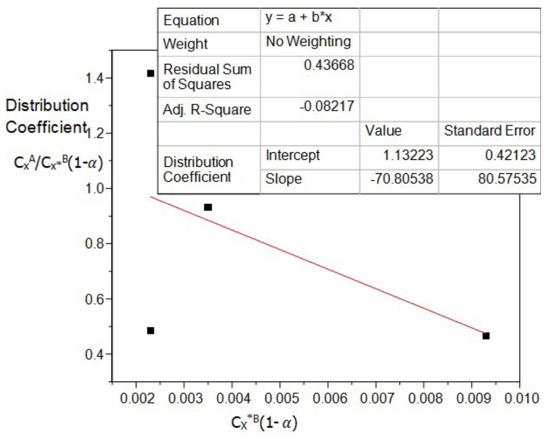

Figure 24: Plot for EDTA in diethyl ether-water at 30°C and atmospheric pressure for the plot $C_x^A/C_{x*}^B(1-\alpha)$ vs $C_x^{*B}(1-\alpha)$, equation (5).

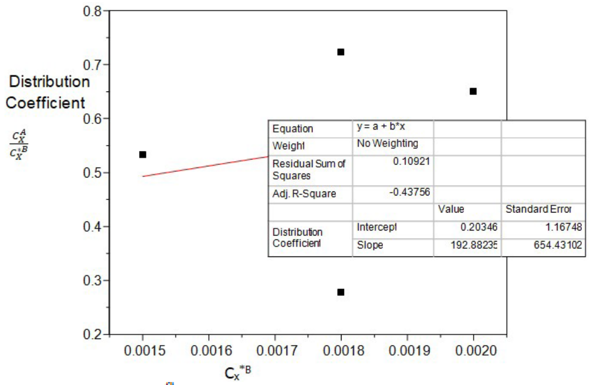

Figure 25: Plot of $\frac{C_X^A}{C_X^{*B}}$ against C_x^{*B} for EDTA in n-hexane-water at 30°C and atmospheric pressure, for equation (3).

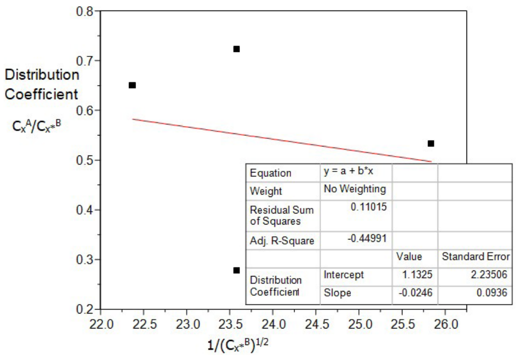

Figure 26: Plot for C_x^A/C_{x*}^B vs $1/(C_{x*}^B)^{1/2}$ for EDTA in n-hexane-water at 30°C and atmospheric pressure, for equation (4).

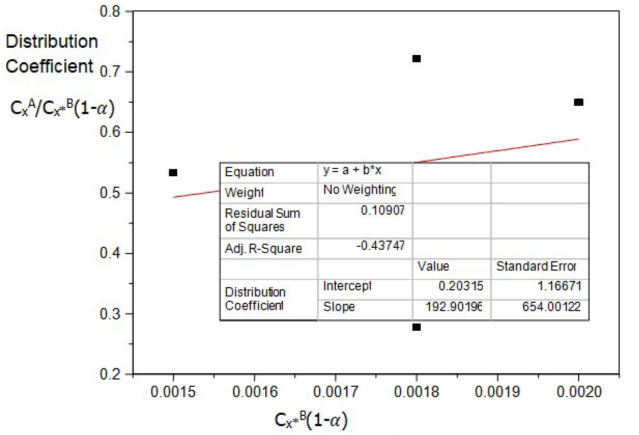

Figure 27: Plot for $C_x^A/C_{x*}^B(1-\alpha)$ vs $C_{x*}^B(1-\alpha)$ for EDTA in n-hexane-water at 30°C and atmospheric pressure, for equation (5).

The results from the research conducted by Onyeocha et. al. [1,2], are shown in Tables 1 – 30 and Figures 1 - 27 below:

Methods

The materials for these works are effluents/contaminants containing oxalic acid, succinic acid or ethylenediaminetetraacetic acid, EDTA, carbon tetrachloride-water as the binary solvent for the extraction of any of these acids. Additionally, diethyl ether-water could also be used as binary solvent for the extraction of EDTA. The partition coefficient values as recorded by Onyeocha et. al are given as follows:

Case I: Oxalic acid has the most relative appreciable partition coefficient value of 0.0738, the dimerization constant value of 15.7092 in magnitude and the ionization constant value of 0.0303 in carbon tetrachloride-water at 30^{0}C and atmospheric pressure. The partition coefficient value of less than one ($k_D < 1$) suggests that the extraction process will be done in more than one step for the complete extraction of oxalic acid (Table 10).

Case II: Succinic acid has the partition coefficient value of 0.0562 in magnitude, the dimerization constant value of 18.5655 in magnitude and ionization constant value of 0.0284 in carbon tetrachloride-water, at 30°C and atmospheric pressure. Also, a multi-step method of extraction will be used for the complete extraction of this acid.

Case III: EDTA has the partition coefficient, k_D, value of 1.9213 in carbon tetrachloride-water, and k_D of 1.2186 in diethyl ether-water systems respectively, the dimerizaation constant, K, of -30.7821, in carbon tetrachloride-water and dimerization constant, K, of -23.8972 in diethyl ether-water systems respectively, and the ionization constant values of 0.0149 in carbon tetrachloride-water and 0.0687 in diethyl ether-water systems respectively, at 30^{0}C and atmospheric pressure. The partition coefficient shows the degree of the extraction of the solute in the solvent that is involved.

Result

Tables 10, 20 and 30 summarized the results of the research for oxalic acid, succinic acid and ethylenediaminetetraacetic acid respectively. From the tables, carbon tetrachloride-water is highlighted as a good solvent for the beneficiation of these solutes that are analyzed. This conclusion is drawn from the appreciable partition coefficient magnitude generated in this medium with the respective solutes.

Conclusion

The use of binary immiscible solvent is the assured cost-effective measure in the control and removal of solutes like oxalic acid, succinic acid, EDTA, etc, from polluting the environment and afflicting the human populace.

References

1. Onyeocha VO. Comparisons of the effects of solute interactions on partition coefficient, kD, in selected binary immiscible solvents: a case of oxalic acid and succinic acid. 2021.
2. Onyeocha VO. Analyses of Ethylenediaminetetraacetic Acid (EDTA) in Selected Binary Immiscible Solvents: The Role of Partition Coefficient, kD. 2022.
3. Onyeocha VO, Akpan OD, Onuchukwu IA, et al. The Dimerization Effects of Some Solutes on the Partition Coefficient (kD) in Binary Immiscible Solvents. Intern. Lett. Chem. Phys. Astrono. 2018; 80: 40–52.
4. Onuchukwu AI: Chemical Thermodynamics for Science Students. Owerri: FUTO Press; 4th ed. 2016; 175.
5. Rastogi RP, Misra RR. An Introduction to Chemical Thermodynamics. India: Vikas Publishing House Pvt Ltd; Second Edition.1980: 296–300.
6. Zenodo. Comparisons of the effects of solute interactions on partition coefficient, kD, in selected binary immiscible solvents: a case of oxalic acid and succinic acid. 2021.