STUDY ON ADSORPTION PARAMETER TO REMOVE ZINC FROM SPENT IPA USING ACTIVATED CARBON

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ABSTRACT

Heavy metal is potential hazard to the environment and cause damage to ecosystems and human health. The Printed Circuit Boards (PCB) contains heavy metal; Zinc was treated by Isopropyl Alcohol (IPA) for washing process. IPA is used widely as a solvent and as a cleaning fluid. However large amount of washed IPA would be produced during operation and this should be treated effectively by proper method. It also requires high cost to treat solvent waste that contains hazardous heavy metal. Moreover the use of adsorbent is necessary to be recovered for reducing the washing operation cost. The adsorption process is used to remove Zinc from spent of IPA using Activated Carbon (AC) as adsorbent. The sample is being characterize before mixing with Activated Carbon and conducted in a shaking incubator for adsorption process. The solution then undergo centrifugation and filtration before analyze using Atomic Absorption Spectroscopy (AAS). The optimum adsorption of Activated Carbon dosage, agitation time and pH are being investigated. The high values of Activated Carbon dosage will increase the surface area with more adsorption site, the more adsorption process occur until reach concentrated limit due to overlapping of adsorption site as result of overcrowding of adsorbent particles. The agitation time is also directly proportional to the adsorption process. On the other hand, removal of Zinc without agitation time was found to be appropriate for maximum adsorption because all the adsorbents surface and quantities are having optimum contact capability with adsorbate (Zinc). The pH value will affect the degree of ionization of a species whereby in this experiment, pH 8 was observed to be the most suitable for adsorption process to occur. In term of isotherms compatibility, adsorption of Zn onto Activated Carbon satisfied the both Langmuir and Freundlich isotherms. As the conclusion, the process is significant to reduce the operating cost of adsorbent reuse and factory's waste disposal cost through waste minimization and health hazard contribute from the heavy metal contaminant. It is alternative way to remove the heavy metal in industrial effluent electronic organic waste discharge.

ABSTRAK

Logam berat adalah potensi bahaya kepada alam sekitar dan menyebabkan kerosakan kepada ekosistem dan kesihatan manusia. Papan Litar Bercetak (PCB) yang mengandungi logam berat; Zink dirawat oleh Isopropyl Alkohol (IPA) untuk proses mencuci. IPA digunakan secara meluas sebagai pelarut dan sebagai cecair pembersihan. Walau bagaimanapun IPA yang dibasuh akan dihasilkan dalam jumlah yang besar semasa operasi dan ini perlu dirawat secara berkesan dengan kaedah yang betul. Ia juga memerlukan kos yang tinggi untuk merawat sisa pelarut yang mengandungi logam berat yang berbahaya. Lebih-lebih lagi penggunaan adsorben adalah perlu bagi mengurangkan kos operasi membasuh. Proses penjerapan digunakan untuk membuang Zink daripada IPA menggunakan Karbon Teraktif (AC) sebagai adsorben. Sampel dicampur dengan Karbon Teraktif dan digoncang dalam inkubator untuk proses penjerapan. Campuran menjalani centrifugation dan penapisan sebelum dianalisis menggunakan Spektroskopi Serapan Atom (AAS). Penjerapan optimum dos Karbon Teraktif, masa pergolakan dan pH disiasat. Pertambahan dos Karbon Teraktif akan meningkatkan luas permukaan dengan tapak penjerapan yang banyak, proses penjerapan yang lebih banyak berlaku sehingga mencapai had pekat yang disebabkan oleh pertindihan laman penjerapan akibat kesesakan zarah adsorben. Masa pergolakan juga berkadar langsung dengan proses penjerapan. Selain itu, penyingkiran Zink tanpa masa pergolakan telah didapati sesuai untuk maksimum penjerapan kerana semua permukaan absorben dan kuantiti mempunyai kenalan keupayaan optimum dengan adsorbate (Zink). Selain itu, nilai pH akan menjejaskan darjah pengionan spesis seperti dalam experimen ini, pH 8 adalah yang paling sesuai untuk proses penjerapan berlaku. Mengikut keserasian isotherm, penjerapan Zn ke Karbon Teraktif menepati kedua-dua Langmuir dan Freundlich isotherm. Kesimpulannya, proses ini adalah penting untuk mengurangkan kos operasi penggunaan semula adsorben dan kos pelupusan sisa kilang dengan meminimumkan sisa dan pencemar logam berat yang menyumbang kepada kesihatan yang berbahaya. Ia adalah cara alternatif untuk menghapuskan logam berat dalam efluen industri elektronik buangan organik.

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Electronic equipment such as printed circuit boards contain heavy metals such as zinc, stannum and bistmuth was treated by Isopropyl Alcohol (IPA) for washing process to remove the heavy metal from the equipment. This heavy metal is potential hazard to the environment and cause damage to ecosystems and human health. As example, lead affects brain development of children and damage to central and peripheral nervous system and kidney damage (Patel, 2000). Zinc is one of the heavy metal that exerts its toxic effect at elevated concentrations and yet industrial effluent, domestic water and other sources of water are often enriched with elevated concentration of the metal. Zinc is a divalent metal and teds to exist in a combine state. Most zinc salts are soluble in water indicating that if this metal is incidentally discharge into surface water, it may exert toxic or harmful effect. Therefore the elimination of this metal from water and waste water is important to protect public health (Eddy et al, 2009). Heavy metals are major pollutants in marine ground, industrial and even treated wastewaters (Mahvi, 2008). Stringent regulations are increasing the demand for new technologies for metal removal from wastewater to attain today's toxicity driven limits. Most of the wastes from the manufacture of Printed Circuit Board (PCB) is currently dewatered and neutralized before being changed to meet environment protection regulation. However, large amount of washed Isopropyl Alcohol would be produced during operation and this should be treated effectively by proper method. Regularly, this solvent waste was being sent to waste treatment company ‘Kualiti Alam’ as schedule waste because the methods of salvaging material from circuit boards are highly destructive and harmful. Therefore, the technique of adsorption of heavy metals can be an effective process for the removal and recovery of heavy metal ions from aqueous solutions to reuse back the Isopropyl Alcohol (IPA). Adsorbent using Activated Carbon (AC) has ability to remove a large variety of compounds from contaminated waters has led to its increased use in the last thirty years. A recent change in water discharge standards regarding toxic pollutants has placed additional emphasis on this technology. For many water treatment applications it has proved to be the least expensive treatment option. Adsorption is particularly effective in treating low concentration waste streams and in meeting stringent treatment levels. One of the major attributes of activated carbon treatment is its ability to remove a wide variety of toxic organic compounds to non-detectable levels (99.99%). Its suitability on a specific application will normally depend on costs as they relate to the amount of carbon consumed (Hemant, 2007).

1.2 PROBLEM STATEMENT

The printed circuit boards contain heavy metal which is Zinc metal. According to some estimates, there is hardly any other product for which the sum of the environmental impacts for raw material, industrial refining and production, use and disposal is as extensive as for printed circuit boards. The methods of salvaging material from circuit boards are highly destructive and harmful. Heavy metal is potential hazard to the environment and cause damage to ecosystems and human health (Hemant, 2007). Zinc is one of the heavy metal that exerts its toxic effect at elevated concentrations and yet industrial effluent, domestic water and other sources of water are often enriched with elevated concentration of the metal. Zinc is a divalent metal and teds to exist in a combine state. Most zinc salts are soluble in water indicating that if this metal is incidentally discharge into surface water, it may exert toxic or harmful effect. Therefore the elimination of this metal from water and waste water is important to protect public health (Eddy et al, 2009). Treatment of heavy metal ions in electronic waste was done through washing using organic solvent such as IPA. However large amount of washed would be produced during operation and this resulted in high cost of treatment and require careful handling of the contaminated IPA effluent that contain high concentration of hazardous heavy metal. As an addition, manufacture must pay outsourcing professional waste treatment companies for further treatment of these wastes which makes the waste treatment cost getting higher, thus potential recycling of the waste becomes more important not only to the environment protection but also for reducing the washing operation cost. Apart from that, this treatment is required to achieve environment regulation and to reduce of heavy metal toxicity through enhanced washing process. As the conclusion, this IPA washing technique could eliminate waste disposal costs, reduce raw material costs and provide income from a salable waste.

1.3 OBJECTIVES

1 To find the optimum activated carbon dosage to the removal of Zinc in IPA.
2. To find the optimum agitation time on the adsorption of Zinc.
3. To find the optimum pH on the adsorption of Zinc.

1.4 RESEARCH SCOPES

In order to achieve the objectives stated above, the following scopes of study have been drawn.

i. The effect of Activated Carbon dosage in adsorption process
ii. The effect of absorbent agitation time
iii. The effect of varying pH on adsorption of Zinc.

1.5 RATIONALE AND SIGNIFICANCE

Based on the research scopes mentioned above, the following rationale and significance that we could get have been outlined.

i. It shall reduce the operating cost of adsorbent reuse
ii. It shall reduce factory' waste disposal cost trough waste minimization.
iii. Alternative way to remove the heavy metal in industrial effluent electronic organic waste discharge.
iv. It shall reduce the health hazard contribute from the heavy metal contaminant
v. To comply with the standard quality of industrial and sewage 1979.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

An increased use of metals and chemicals in the process industries has resulted in the generation of large quantities of aqueous effluents that contain high levels of heavy metals, thereby creating serious environmental disposal problems. Exponential growth of the world's population over the past 20 years has resulted in environmental build up of waste products, of which heavy metals are of particular concern. In 1978, the United States environmental protection agency (USEPA) prepared a list of 129 organic and inorganic pollutants found in wastewater that constitute serious health hazards. This list, known as the Priority Pollutants List, includes the following thirteen metals: antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. Unlike organic compounds, metals are non-biodegradable and, therefore, must be removed from wastewater (Keith et al, 1979). Heavy metals, which are not biodegradable are therefore of great concern because they are being added to soil, water and air in increasing amounts. Some, for example, copper, manganese and zinc are micro nutrients though essential in small amounts for plant and animal life can however be harmful if taken up by plants or animals in large amounts, like other heavy metals not known to be essential nutrients. Zinc is present in the air, soil, water and almost all food. Zinc is naturally released into the environment, although industrial activities are mostly responsible for zinc pollution. Mining and foundry activities, zinc, lead and cadmium refining, steel production, carbon combustion and solid waste incineration contribute most significantly to environmental zinc pollution. Water reservoirs are contaminated by the run-off from these industries. The need for economical and effective methods for removing heavy metals from wastewater has therefore resulted in the search for other materials that may be useful in reducing the levels of heavy metals in the environment. Since most conventional methods are neither effective nor economical, especially when used for the reduction of heavy metal ions to low concentrations, new separation methods are required to reduce heavy metal concentrations to environmentally acceptable levels at affordable cost. Thus, additional treatment such as ion exchange, reverse osmosis or adsorption processes are required in order to purify the effluent prior to discharge. Metals removal has been achieved by adsorption on different materials such as activated carbon, agricultural waste, moss peat, minerals, amongst others. Over the past 30 years, adsorption onto activated carbon has been successfully applied for treating municipal and industrial wastewater and drinking water. Successful removal of heavy metals from aqueous solutions using activated carbon has recently been demonstrated. Carbon adsorption is considered the best available technology for eliminating non-biodegradable and toxic organic compounds from aqueous solutions. Activated carbon is considered the universal adsorbent because its inherent physical properties, large surface area, porous structure, high adsorption capacity and extensively reactive surface, make it extremely versatile (Bansal et al, 1988). Although, the efficacy of activated carbon as adsorbents for heavy metals from wastewater is high enough, significant costs involved in its preparation and regeneration limits its use only at the tertiary step in the treatment of wastewaters (Opeolu et all, 2010).

2.2 ISOPROPYL ALCOHOL

Isopropyl alcohol (also Isopropanol, propan-2-ol, 2-propanol or the abbreviation IPA) is a common name for a chemical compound with the molecular formula C_3H_8O. It is a colorless, flammable chemical compound with a strong odor. It is the simplest example of a secondary alcohol, where the alcohol carbon is attached to two other carbons sometimes shown as $(CH_3)_2CHOH$. It is a structural isomer of propanol. Isopropyl Alcohol dissolves a wide range of non-polar compounds. It also evaporates quickly and is relatively non-toxic, compared to alternative solvents. Thus it is used widely as a solvent and as a cleaning fluid, especially for dissolving oils. Examples of this application include cleaning electronic devices such as printed circuit board, contact pins (like those on ROM cartridges), magnetic tape and disk heads (such as those in audio and video tape recorders and floppy disk drives), the lenses of lasers in optical disc drives (e.g. CD, DVD) and removing thermal paste from heat sinks and IC packages (such as CPUs.) Isopropyl Alcohol is used in keyboard, LCD and laptop cleaning, is sold commercially as a whiteboard cleaner, and is a strong but safer alternative to common household cleaning products.

Alcoholic molecule is composed of a hydrophilic part, -OH, and a hydrophobic part, i.e., alkyl group. Since alcoholic molecules were also observed to adsorb onto the activated carbon, the alcoholic molecules can be supposed to have an orientation with the hydrophobic alkyl groups to the surface of adsorbent when they adsorb. As a result, the hydroxyl groups will be strongly hydrated, which may result in the decrease of the adsorption of metal ions (Choi et al, 2001).

2.3 PRINTED CIRCUIT BOARD

A printed circuit board, or PCB, is used to mechanically support and electrically connect electronic components using conductive pathways, tracks or signal traces etched from copper sheets laminated onto a non-conductive substrate. The printed circuit boards contain heavy metals such as zinc, silver, lead, tin and copper was treated by Isopropyl Alcohol for washing process. It dissolves a wide range of non-polar compounds relatively non-toxic and evaporates quickly. Thus it is used widely as a solvent and as a cleaning fluid especially in electronic industries. According to some estimates, there is hardly any other product for which the sum of the environmental impacts for raw material, industrial refining and production, use and disposal is as extensive as for printed circuit boards. Electronic product developers are introducing chemicals on a scale which is incompatible with the limited knowledge of their environmental and biological impacts. When these items are dumped into landfills or improperly recycled, they pose a significant hazard to the environment and human health. Hazardous waste treatment involves almost anything that can be done to a hazardous waste prior to disposal. Any method, technique or, process designed to change the physical, chemical, or biological character or composition of the hazardous waste, so as to neutralize the waste or to make the waste less hazardous and thereby safer for transport, increase potential for recovery, reuse or storage, or to reduce waste volume. Therefore, the solvent waste of isopropyl alcohol that contains heavy metal by washing process was necessary to require a treatment.

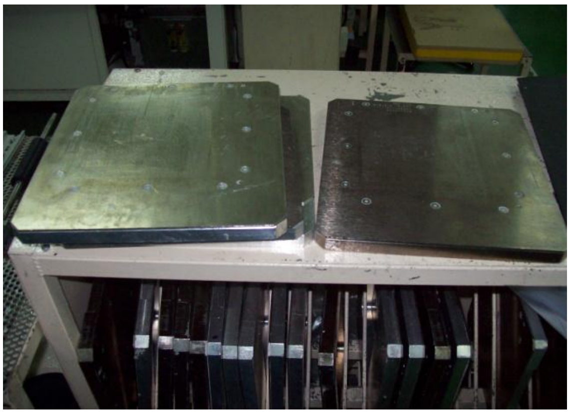

Figure 2.1: Printed circuit board

2.4 ZINC METAL

Zinc is a lustrous bluish-white metal. It is found in group IIb of the periodic table. It is brittle and crystalline at ordinary temperatures, but it becomes ductile and malleable when heated between 110°C and 150°C. It is a fairly reactive metal that will combine with oxygen and other non-metals, and will react with dilute acids to release hydrogen. It is used principally for galvanizing iron, more than 50% of metallic zinc goes into galvanizing steel, but is also important in the preparation of certain alloys. It is used for the negative plates in some electric batteries and for roofing and gutters in building construction. Zinc is commonly used to coat iron and other metals for prevention of oxidation. Various zinc salts are used industrially in wood preservatives, catalysts, photographic paper, and accelerators for rubber vulcanization, ceramics, textiles, fertilizers, pigments and batteries. Zinc occurs naturally in air, water and soil, but zinc concentrations are rising unnaturally, due to addition of zinc through human activities. Most zinc is added during industrial activities, such as mining, coal and waste combustion and steel processing. Some soils are heavily contaminated with zinc, and these are to be found in areas where zinc has to be mined or refined, or were sewage sludge from industrial areas has been used as fertilizer.

Zinc is a very common substance that occurs naturally. Many foodstuffs contain certain concentrations of zinc. Drinking water also contains certain amounts of zinc, which may be higher when it is stored in metal tanks. Industrial sources or toxic waste sites may cause the zinc amounts in drinking water to reach levels that can cause health problems. Zinc is a trace element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. Zinc-shortages can even cause birth defects. Although humans can handle proportionally large concentrations of zinc, too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anaemia. Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. Extensive exposure to zinc chloride can cause respiratory disorders.

Water is polluted with zinc, due to the presence of large quantities of zinc in the wastewater of industrial plants. This wastewater is not purified satisfactory. One of the consequences is that rivers are depositing zinc-polluted sludge on their banks. Zinc may also increase the acidity of waters. Some fish can accumulate zinc in their bodies, when they live in zinc-contaminated waterways. When zinc enters the bodies of these fish it is able to bio magnify up the food chain. Large quantities of zinc can be found in soils. When the soils of farmland are polluted with zinc, animals will absorb concentrations that are damaging to their health. Water-soluble zinc that is located in soils can contaminate groundwater. Finally, zinc can interrupt the activity in soils, as it negatively influences the activity of microorganisms and earthworms. The breakdown of organic matter may seriously slow down because of this.

2.5 ADSORPTION PROCESS

Adsorption is a process which uses a solid to remove particles from a liquid or gas that passes across it. The particles stick to its surface. Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent, or metallic) of the constituent atoms of the material are filled by other atoms in the material. However, atoms on the surface of the adsorbent are not wholly surrounded by other adsorbent atoms and therefore can attract adsorbates. The exact nature of the bonding depends on the details of the species involved, but the adsorption process is generally classified as physisorption (characteristic of weak van der Waals forces) or chemisorption (characteristic of covalent bonding). It may also occur due to electrostatic attraction. Activated carbon adsorption proceeds through three basic steps;

1. Substances adsorb to the exterior of the carbon granules
2. Substances move into the carbon pores
3. Substances adsorb to the interior walls of the carbon

This process creates a film of the adsorbate (the molecules or atoms being accumulated) on the surface of the adsorbent. It differs from absorption, in which a fluid permeates or is dissolved by a liquid or solid. The term sorption encompasses both processes, while desorption is the reverse of adsorption. Adsorption is usually described through isotherms, that is, the amount of adsorbate on the adsorbent as a function of its pressure (if gas) or concentration (if liquid) at constant temperature (Geankoplis, 1995). The quantity adsorbed is nearly always normalized by the mass of the adsorbent to allow comparison of different materials. A sorption isotherm (also adsorption isotherm) describes the equilibrium of the sorption of a material at a surface (more general at a surface boundary) at constant temperature. It represents the amount of material bound at the surface (the sorbate) as a function of the material present in the gas phase and/or in the solution. Adsorption carbons have played a major role in the development of adsorption technology. Adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Adsorption occurs when the attractive forces at the carbon surface overcome the attractive forces of the liquid (Austin, 1992).

2.6 ADSORBENT

An adsorbent is a substance, usually porous in nature and with a high surface area that can adsorb substances onto its surface by intermolecular forces. Only at very low concentrations is the adsorption isotherm linear, at higher concentrations the adsorption isotherm may be Langmuir or Freundlich in nature. Due to the fact that solutes can distribute between the adsorbent surface and a mobile phase, adsorbents are used as a stationary phases in gas-solid and liquid-solid chromatography. Adsorbents are also used for extraction purposes removing traces of organic materials from large volumes of water very efficiently (solid phase extraction devices). Typical adsorbents used in gas-solid chromatography are silica gel, alumina, carbon and bonded phases. These are mostly used in the separation of the permanent gases and the low molecular weight hydrocarbon gasses. Adsorbents used in liquid solid chromatography are mostly silica gel and various types of bonded phases. Adsorbents in liquid-solid chromatography have a very wide variety of application areas.

Major types of adsorbents in use such as activated alumina, silica gel, activated carbon, molecular sieve carbon, molecular sieve zeolites and polymeric adsorbents. Most adsorbents are manufactured (such as activated carbons), but a few, such as some zeolites, occur naturally. Each material has its own characteristics such as porosity, pore structure and nature of its adsorbing surfaces. Pore sizes in adsorbents may be distributed throughout the solid. Pore sizes are classified generally into three ranges which is macropores that have diamaters in excess of 50-nm, mesopores (also known as transitional pores) that have diameters in the range 2 - 50-nm, and micropores that have diameters which are smaller than 2-nm. Many adsorbent materials, such as carbons, silica gels and aluminas, are amorphous and contain complex networks of inter-connected micropores, mesopores and macropores. In contrast, pores in zeolitic adsorbents have precise dimensions.

Adsorbents are used usually in the form of spherical pellets, rods, moldings, or monoliths with hydrodynamic diameters between 0.5 and 10 mm. They must have high abrasion resistance, high thermal stability and small pore diameters, which results in higher exposed surface area and hence high surface capacity for adsorption. The adsorbents must also have a distinct pore structure which enables fast transport of the gaseous vapors. Most industrial adsorbents fall into one of three classes:

- Oxygen-containing compounds – Are typically hydrophilic and polar, including materials such as silica gel and zeolites.
- Carbon-based compounds – Are typically hydrophobic and non-polar, including materials such as activated carbon and graphite.

- Polymer-based compounds - Are polar or non-polar functional groups in a porous polymer matrix.

Activated carbon is used for adsorption of organic substances and non-polar adsorbates and it is also usually used for waste gas (and waste water) treatment. It is the most widely used adsorbent since most of its chemical (e.g. surface groups) and physical properties (e.g. pore size distribution and surface area) can be tuned according to what is needed. Its usefulness also derives from its large micropore (and sometimes mesopore) volume and the resulting high surface area.

2.7 ACTIVATED CARBON

In selecting a good adsorbent, several criteria need to be considered. A good adsorbent must have high abrasion resistance, high thermal stability and small pore diameters, which results in higher exposed surface area and hence high surface capacity for adsorption. The adsorbents must also have a distinct pore structure which enables fast transport of the gaseous vapors. Generally this means that a good adsorbent will be very porous, full of many tiny little holes on its surface that effectively increase its surface area by many times.

Activated carbon is a highly porous, amorphous solid consisting of microcrystallites with a graphite lattice, usually prepared in small pellets or a powder. It is non-polar and cheap. One of its main drawbacks is that it is reacts with oxygen at moderate temperatures (over 300 °C). Activated carbons (ACs), which are produced by either thermal activation or chemical activation, have a large surface area, a broad range of pore size distribution and extremely cheap. Activated carbons consist of small hexagonal carbon rings, which are called ‘‘graphene sheets’’. Different size orientation and stacking of these sheets can be achieved by adjusting the carbon preparation method. But, in general, an activated carbon has an amorphous structure and lacks long range three-dimensional order. Activated carbon is used for adsorption of organic substances and non-polar adsorbates and it is also usually used for waste gas (and waste water) treatment. It is the most widely used adsorbent since most of its chemical (eg. surface groups) and physical properties (e.g. pore size distribution and surface area) can be tuned according to what is needed. Its usefulness also derives from its large micropore (and sometimes mesopore) volume and the resulting high surface area. The adsorption capacities of the modified AC samples towards the heavy metal ions were estimated. The mechanisms of adsorption processes of metal species on AC surfaces were extensively studied and described on the basis of their electrochemical behavior (Radhi et al, 2010).

Figure 2.2: Activated Carbon

Adsorption using granular activated carbon (GAC) is the most commonly-used adsorbent in water treatment. Granular activated carbon is a particularly good adsorbent medium due to its high surface area to volume ratio. The specific capacity of a granular activated carbon to adsorb organic compounds is related to molecular surface attraction, the total surface area available per unit weight of carbon, and the concentration of contaminants in the wastewater stream. Granular activated carbon has a relatively larger particle size compared to powdered activated carbon and consequently, presents a smaller external surface. Diffusion of the adsorbate is thus an important factor. These carbons are therefore preferred for all adsorption of gases and vapors as their rate of diffusion are faster. Granulated carbons are used for water treatment, deodorization and separation of components of flow system. GAC can be either in the granular form or extruded. One gram of a typical commercial activated carbon will have a surface area equivalent to 1,000 square meters. This high surface area permits the accumulation of a large number of contaminant molecules. Granular activated carbon is a particularly good adsorbent medium due to its high surface area to volume ratio. One gram of a typical commercial activated carbon will have a surface area equivalent to 1,000 square meters. This high surface area permits the accumulation of a large number of contaminant molecules. The specific capacity of a granular activated carbon to adsorb organic compounds is related to molecular surface attraction, the total surface area available per unit weight of carbon, and the concentration of contaminants in the wastewater stream. The basic instrument for evaluating activated carbon use is the adsorption isotherm.

Adsorption using activated carbon is rapidly becoming a prominent method of treating aqueous effluents and has been used in industrial processes for variety of separation and purification process. Since its first introduction for heavy metal removal, activated carbon has undoubtedly been the most popular and widely used adsorbent in wastewater treatment applications throughout the world. In spite of its prolific use, activated carbon remains an expensive material since higher the quality of activated carbon, the greater its cost. Activated carbon also requires complexity agents to improve its removal performance for inorganic matters. Therefore, this situation makes it no longer attractive to be widely used in small-scale industries because of cost inefficiency (Sandya et al, 2002). Among them, activated carbon, which is characterized by high adsorption capacity, allowing application under broad pre-concentration conditions due to its ability to adsorb organic compounds and organic metal complexes, has widespread application for trace element pre-concentration. Because activated carbon is a type of hydrophobic adsorbent which adsorbs non-polar or little polar substances in aqueous solution, metal ions to be preconcentrated need to be transformed corresponding metal chelates or precipitate or metal hydroxides which could be adsorbed on activated carbon. Metal chelates could provide higher selectivity and high enrichment factors for such a pre-concentration and separation. The mechanism involved in the adsorption of ions as trace compounds by activated carbon is not completely known. The mechanism of sorption is still under investigation and the adsorption of heavy metals on Activated Carbon could be explained using Langmuir and Freundlich equations (Farshid et al, 2009). Adsorption efficiency decreases over time and eventually activated carbon will need to be replaced or reactivated.

2.8 ADSORPTION ISOTHERMS

Isotherms are empirical relations which are used to predict how much solute can be adsorbed by activated carbon. Adsorption isotherms, actually give the amount of the adsorbate adsorbed per unit mass or volume of adsorbent as a function of the concentration or pressure of the adsorbate in the fluid. The linear isotherm corresponds to a constant distribution of coefficient (the ration of the concentration on the solid to the concentration in the fluid). Linear isotherm implies that a molecule of an adsorbate has a given probability of being adsorbed that is independent of the concentration of the adsorbate (solute). The active sites, surface, or volume of the adsorbent are largely unfilled with adsorbents, so the chemical activity of the adsorbent surface is approximately constant. Even a non linear adsorption isotherm, may be approximately linear over the concentration region of interest (i.e. from minimum concentration to maximum concentration of the adsorbate expected).

The Langmuir and Freundlich equation are two (equilibrium-based models) of the most widely used and are incorporated in the following work. Both models allow one to summarize and compare adsorption data and possibly even to predict adsorption data and possibly even to predict adsorption behavior outside of experimental conditions. However, these isotherms do not specifically indicate the type of sorption mechanism responsible for adsorption, nor do they provide the speciation of surface complexes. Langmuir isotherm is a non linear isotherm and is based on the following assumptions.

- Adsorption cannot proceed beyond monolayer coverage.
- All surface sites are equivalent and can accommodate, at most, one adsorbed atom.
- The ability of a molecule to adsorb at a given site is independent of the occupation of neighboring sites.

The Langmuir adsorption isotherm is perhaps the best known of all isotherms describing adsorption and is often expressed as:

$$Qe = XmKCe/ (1 + KCe) \qquad \text{(Equation 2.1)}$$

Where;

Qe is the adsorption density at the equilibrium solute concentration Ce (mg of adsorbate per g of adsorbent).

Ce is the concentration of adsorbate in solution (mg/L).

Xm is the maximum adsorption capacity corresponding to complete monolayer coverage (mg of solute adsorbed per g of adsorbent).

K is the Langmuir constant related to energy of adsorption (L of adsorbent per mg of adsorbate).

The above equation can be arranged to the following linear form:

$$Ce/Qe = 1/XmK + Ce/Xm \qquad \text{(Equation 2.2)}$$

The linear form can be used for linearization of experimental data by plotting Ce/Qe against Ce. The Langmuir constant Xm and K can be evaluated from the slope and intercept of linear equation.

The Freundlich isotherm is an empirical equation for non ideal systems. The freundlich isotherm is known relationship describing the adsorption equation and is often expressed as:

$$Qe = K_f Ce^{1/n} \qquad \text{(Equation 2.3)}$$

Where;

Qe is the adsorption density (mg of adsorbate per g of adsorbent).

Ce is the concentration of adsorbate in solution (mg/L).

K_f and n are the empirical constants dependent on several environmental factors and n is greater than one.

The equation is conveniently in the linear form by taking the logarithmic of both sides as;

$$\ln Qe = \ln K_f + 1/n \ln Ce \qquad \text{(Equation 2.4)}$$

A plot of lnCe against lnQe yielding a straight line indicates the confirmation of the Freundlich isotherm for adsorption. The constants can be determined from the slope and the intercept (Afridi, 2008).

These dimensionless, empirical constants are useful for comparing the adsorption capacities for different compounds or for assessing the adsorption capacities of various activated carbons. Liquid phase adsorption isotherms have been developed for most commercial activated carbons for a variety of specific compounds. Figure I present a typical adsorption isotherm used to predict activated carbon adsorption capacity. An isotherm is specific to a particular contaminant and the type of activated carbon used (Austin, 1992).

CHAPTER 3

METHODOLOGY

3.1 FLOW CHART

3.1.1 Flow chart of Activated Carbon preparation

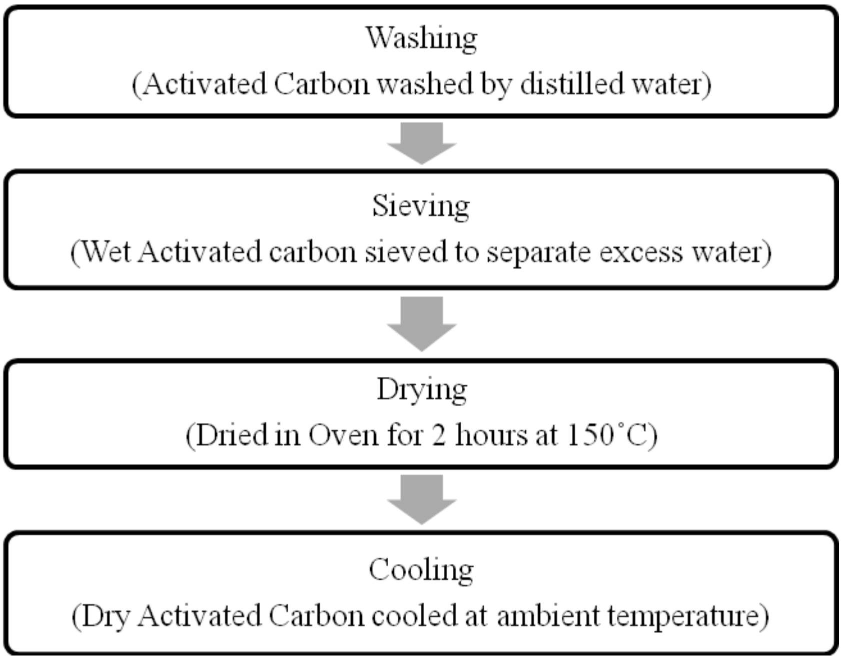

Figure 3.1: Process Flow for activated carbon preparation

3.1.2 Overall Adsorption Process for Activated Carbon Dosage, Agitation Time and pH

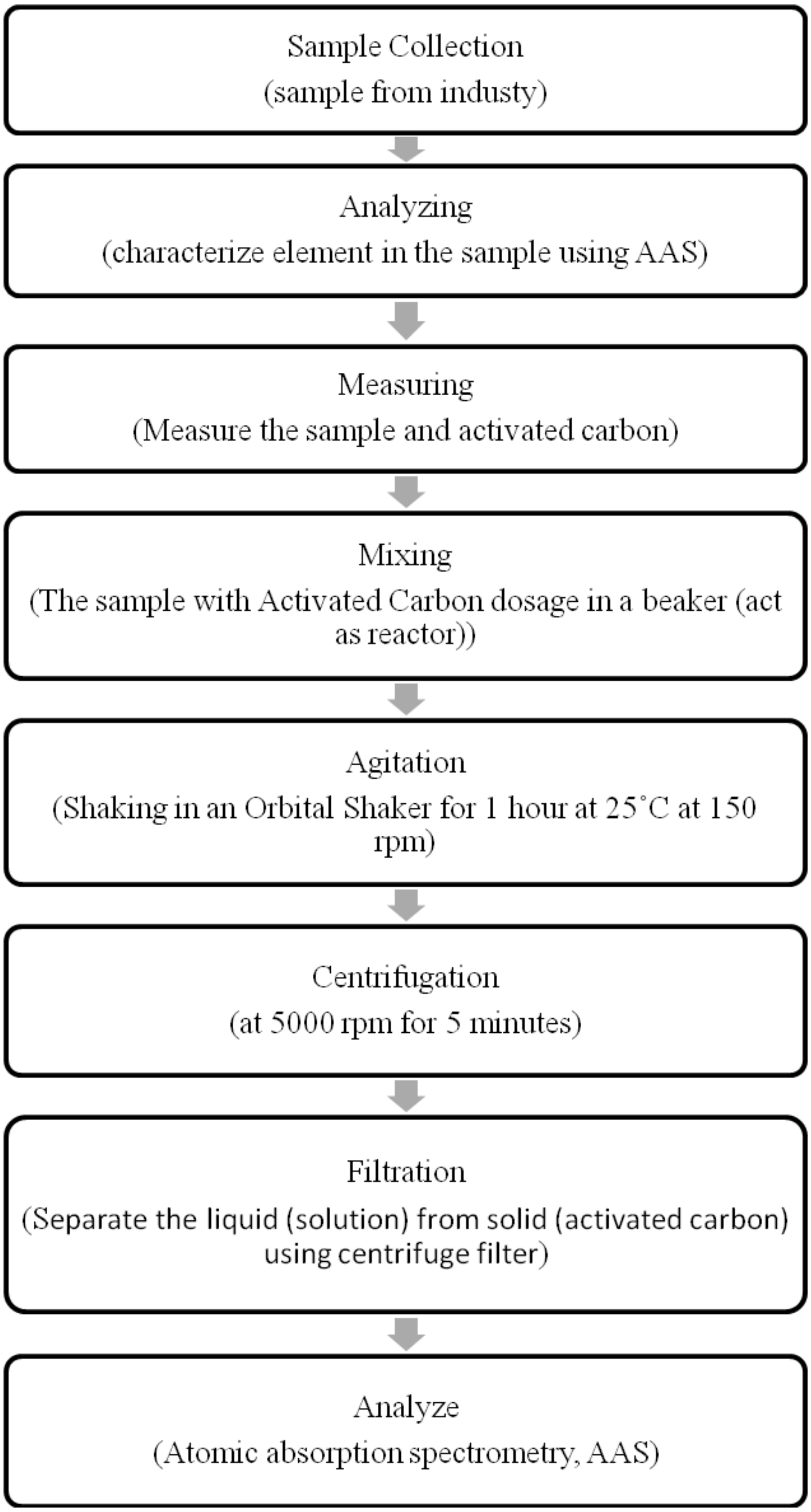

Figure 3.2: Overall process Flow for adsorption process

3.1.2.1 Flowchart of Activated carbon dosage experiment

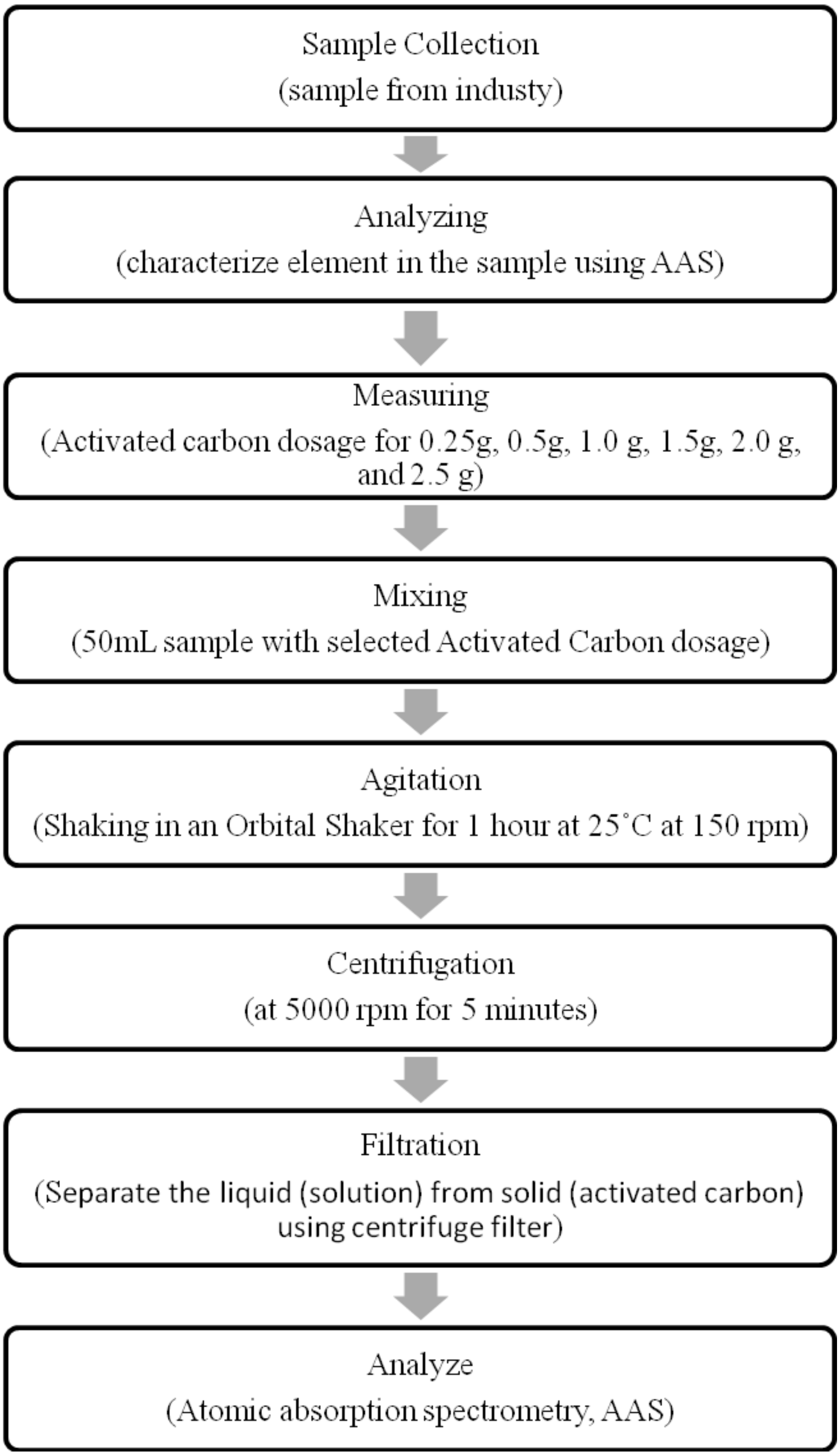

Figure 3.3: Process flow for Activated Carbon Dosage

3.1.2.2 Flowchart of Agitation time experiment

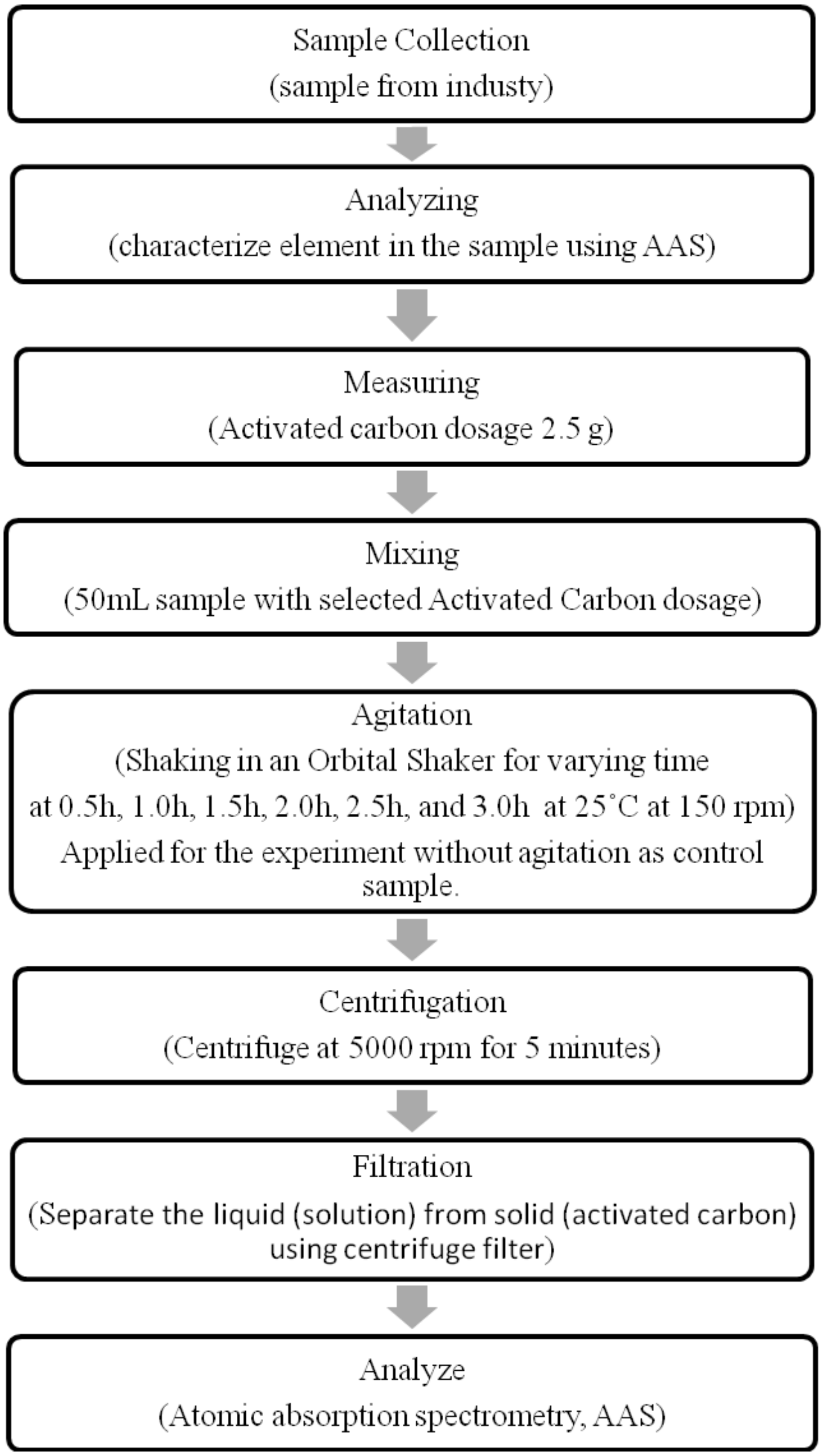

Figure 3.4: Process flow for different Agitation Time

3.1.2.3 Flowchart of pH experiment

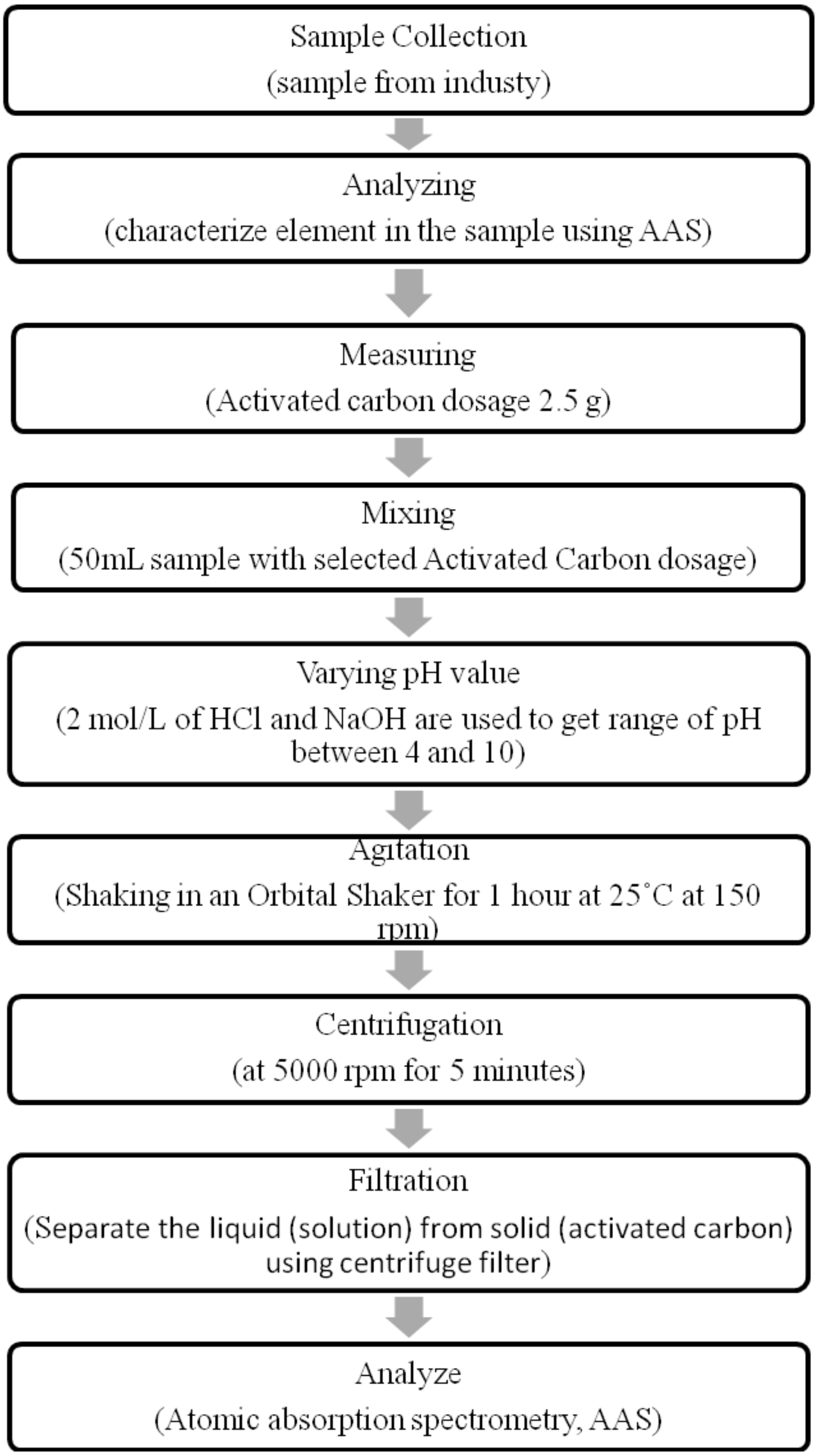

Figure 3.5: Process flow for varying pH

3.2 DESCRIPTION

3.2.1 Introduction

In this chapter, a detail experiment outline will be presented, which includes materials and apparatus to be used, description of experimental scale and also sequence of experimental procedures. The main purpose of this study are to remove the Zinc from spent of isopropyl alcohol by investigate the impact of activated carbon dosage to the removal of Zinc in isopropyl alcohol, the effect of agitation time on the adsorption of heavy metal, and the effect of varying pH on the adsorption of Zinc. It is a batch-type contact operation where a quantity of carbon is mixed with continuously with a specific volume of water or waste until the pollutant in that solution has been decreased to a desired level.

3.2.2 Material

The following chemicals will be employed for the adsorption and oxidation process:

1. Sample of electronic organic waste (mixtures of IPA and heavy metal)
2. Granular Activated Carbon (GAC) with size range 20-40 mesh.
3. Hydrochloric Acid (HCl)
4. Sodium Hydroxide (NaOH)
5. Distilled water & Ultrapure (H_2O)

Figure 3.6: Waste Isopropyl Alcohol