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Radiation Application in Consumers' and Health Applications – A Preliminary Review

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ABSTRACT

Irradiation method has received a tremendous attention in recent years especially as a consumer and health application. For consumer product, any compound that can be used as a cleaning agent is known as a detergent. Detergents are known with their natural radioactivity levels like other industrial products. While in the health application, generally people in many regions of the world still do not get enough iodine and iodine deficiency remains a public health issue. Around 30 % of the world's population is at danger of iodine deficiency. According to Oxford Advances Learning Dictionary, the word adsorb is defined as the accumulation of liquid or gas on surface of a substance. Meanwhile, thyroid is gland in the neck that produces hormone which regulate and control the body growth and function. Thus, from this review, the topic is basically about the effects when iodine is adsorbed in the thyroid gland that could cause thyroid disease. Review on the irradiated detergent is also presented.

1. Introduction

1.1 Detergent as Cleaning Agent

Detergents are widely used in industrial processes. This can be proved by statistics that shows a worldwide investment of roughly $60 billion per year for cleaning products [1,2]. Detergent is not limited for household cleaning and laundering industry use only [3,4]. They also used as fuel additives to manufacture biological molecules [5].

Both soap and detergent are surfactants, basically there have same structural characteristics which are polar region and non-polar region. This characteristics describe the interaction of soap and fats with water. There are four types of surfactants which are anionic, cationic, non-ionic and amphoteric [6,7]. Surfactant that contain cleaning agent e.g. alkyl benzene sulphate of sodium are known as anionic synthetic detergent. Anionic surfactant is most applicable for washing due to ability to remove the dirt. When it mixes with the water solvent, the fabric surface and dirt particle are negative charged. Anionic surfactants are essential surfactants that are used in detergent and cosmetic products. Over the years, many surfactants are produced to improve their performance in detergent formulation such as highly soluble alcohol sulphates (HSAS) which allow better surface

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activity and solubility and is modified with linear alkyl benzene sulfonates (MLAS) to become favourable biodegradability and high solubility [8]. Non-ionic surfactants interact with water molecules and are absent of any radicals with the electric charges. This surfactant is commonly used as hair conditioner and also fabric softener. For amphoteric surfactant or is also familiar as 'zwitterionic' surfactant, it has both positive and negative charges which is commonly used in cosmetic cream and shampoo [9].

Surfactant properties of protein are amphiphilic. Amphiphilic means surfactant has hydrophilic group for their head and hydrophobic group at their tail. Based on [10], this propertie interface with the layer so they can attract to their own segment pair e.g. the hydrophobic segment interact with the air or oil which acts as the hydrophobic phase, while the aqueous phase attracts to hydrophilic. Nowadays, most of the synthetic detergent contain phosphates which leads to serious environmental problem [11]. The issue of detergents to the environment is growing quickly in evolving countries and rural communities [12]. Phosphate is one of the sequestering and chelating agents that can increase cleaning power of the detergent when it is added into it [13]. This will increase the efficacy of the detergent with low cost. In the presence of water, phosphate will remove the magnesium and calcium ions that can lessen the reaction of detergent.

By acting as nutrient, the phosphate will trigger the growth of algae and cause eutrophication. The phosphates also help the formation of white foam which function as a barrier to entry of oxygen and light in the water. As the result, detergents prevent the growth of microorganisms that are pathogenic species in nature with higherloads in river [14]. In addition, the presence of phosphate lead detergent reduces the water quality at the environment [15]. According to previous study, benzalkonium chloride (BAC) and linear alkylbenzene sulfonate (LAS) are anionic surfactants and have been reported the risk toxicity to the ecosystem. They contain significant amounts of phosphates in the anionic surfactant which leads to eutrophication of water resources [8].

The lack of knowledge of their degradation in the environment about phosphate product can lead to a more serious matter. People must limit the phosphate that are used in synthetic detergent and also reduce the fertilizer that contain this material where the waste will flow through universal medium which is water [16]. Most of the region in the world decide to introduce first laws that banned the addition of phosphate in their area as awareness of uncontrollable phosphate usage. Germany, Austria, Belgium, Ireland and Italy are some of the countries that have established legislation, to limit the addition of phosphates in detergents for clothes and to reduce the environmental problem [16].

2. Soap as the Basic of Detergent Production

The origin of soap are unclear, but there are some previous research recorded that soap came from the Latin word which is known as *sapo*. Laundry detergents used soaps as complexing or defoaming agents. Soap perform supportable characteristic in detergent formulation. The interaction of fatty acid with the alkali results in production of emulsifiers. In addition, soaps acts as anti-foaming and wetting agents able to improve laundry detergent action and reduce foam formation in washing machines [8]. Sodium hydroxide and sodium bicarbonate are the main ingredients of hard soap, which takes on a greyish-white colour when it becomes cold and dry. It is used mainly for external cleansing purposes.

These major product of chemical reactions between triglyceride which is fixed oil from seed and lye solution [17]. Vegetable oil and animal fats are traditional materials that are saponified. In aqueous medium, these materials called as triglycerides which can react with a strong mineral base e.g. sodiumhydroxide to produce the sodium salts of the hydrolyzed free fatty acids which is the

opaque soap and glycerol [18,19]. Historically, at first they reuse animal fats, lard and sebum as one of the method of soap production [20]. Soap are extensively used, but there still have families and communities in poor regions produce their own soap bars [21]. The production of soap by their own lead in risk of infection due to not secure the method of soap made in some area [22].

By consideration for better health and skin, good quality of the green soap was introduced [22]. In this era, the uses of fat as sources have been dominant in soap production. In addition, this also have development by considering the number of different oils and fats also additives that assist the power cleaning. Previous research shows the potential of seed oils such as shear butter, neem seed oil and palm kernel oil for improvement in soap production by varied their characteristics [23,24]. Selection of the oil type in the production of soap need to be concern more, this is due to consider the presence of natural characteristic aroma, clarity, natural colour, low moisture content and absence of flat and odour [25,26]. The best quality of bar soaps can be recognized based on some criteria such as soap hardness, cleansing power, conditioning, lathering potential and antiseptic nature [27]. Consequently, the result of various combinations in the reaction of oils or fat in different proportion with lye lead to excellent quality soap synthesized [26]. Hence, the characteristic of the good quality soap are safer to be used based on varies human skin.

3. Radiation on Detergent

In physics, radiation is the emission of wave that transmit energy through a medium or material that acts as radiant element. For a long duration it may harm to people if exposure to this emission have no limit. Gamma rays, x-rays and ultraviolet light are range of electromagnetic wave that are ionizing radiation. Radiation as the physical alteration can damage cells in two ways which is direct and indirect effect. Direct effect allows the damaging through DNA and other cellular targets. While, for indirect effect damaging cell occurs through producing reactive oxygen species (ROS) [28]. In fact, radiation also have significant role to our life especially on life science and medicine field [29].

Every product is made from raw material compounds, the raw material can emit radiation originated from the nature, animals, plants, metals and oil [30]. As shown in Figure 1, the presence of radioactivity level in detergents exist in all the detergent samples investigated [31]. In addition, a previous study has investigated the removal of detergent using polymeric material and gamma radiation and the results show that the degradation using gamma radiation was one of best method for removal detergent in waste water [32].

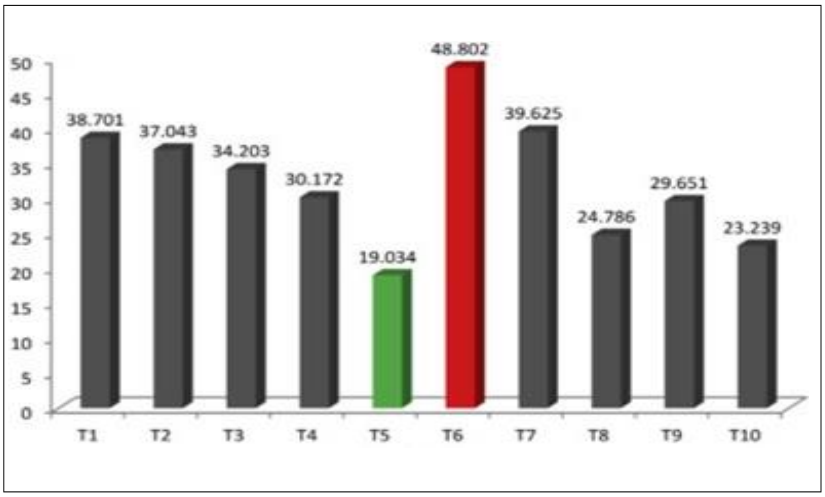

Fig. 1. Graph on radioactivity level in detergent sample. Radium equivalent activity *vs.* Samples [31]

4. Bovine Serum Albumin (BSA) as a Transportation of Biological Activity

BSA is one of the group of proteins that are widely studied because of its fundamental homology with human serum albumin (HSA) [33]. Proteins are one of the primary components of the living cells that contribute for the growth and activities of the biological systems. The interactions of proteins with other molecules such as surfactants have a significant importance due to fascinating structural organization as well as their potential technological applications in industry, biology, pharmaceutical and personal care products [34]. There are many different techniques to clarify protein structural change and binding mechanism of surfactant and protein from previous study [35]. According to [36], the characterization of amino acid in BSA are state around 582 to 607.The three-dimensional structures of albumins bear a resemblance to a heart and consists of 6 sub-domains that repeat the α-helix pattern.

BSA has several essential physiological and pharmacological functions. All the transportation of metals, fatty acids, cholesterol, pigments and drugsare shouldered by serum albumin [37]. It has significant role in the transport and disposition of endogenous and exogenous ligandspresent in blood as one of the most important carrier proteins [33]. BSA is able to implement with the different conformations, as we vary the pH and ionic strength [38] for example, as the investigation of which associate the behaviours between biliverdin and BSA by fluorescence spectroscopy. In addition, a previous study shows a changes of pH influences the BSA structure [38]. According to [39], the high energy of UV radiation can be absorbed by epidermis and give significant toxicity towards skin capillaries including blood and albumin.

5. Health Applications

5.1 Iodine Properties

Iodine plays a crucial role in our body metabolism. It is a trace element that is critical for normal function of the thyroid gland, which is a key regulator of the body's basic metabolic rate that is needed in just small amounts [40]. About more than 1.6 billion people is lacking in iodine consumption in their meals, resulting in various cases of iodine deficiency disorders [41]. Iodine is well known as being volatile that exist in nature. It sublimes when heated releasing the iodine vapour. Iodine stability is affected by humidity of atmosphere, moisture content in salt, light, impurities in salt, alkalinity or acidity and the form of iodine present. Iodine content will be constant if kept in cool, dry container with an impervious lining and away from light. People are unrealized that the way they cook and store iodize salt could actually make the iodine content in the salt disappear. The recommend iodization level is 40-50 ppm [42].

5.2 Determination of Iodine Content

In order to find the iodine content in the table salt, the iodometric titration method is used. In previous research, iodated salts were obtained from their production sites as well as from the supermarket and packed into a high density polyethylene (HDPE) bags with production and expiring dates as well as the iodine concentration clearly stated. Some raw non-iodated salts were also sampled. These samples were taken at the site at the time of harvesting. The samples were exposed to different storage conditions which included refrigeration, storage in laboratory cupboards and exposure to direct sunlight to mimic conditions under which salts are usually stored at home for use [43]. The results showed that the iodine concentration in salts decreased after days of exposure. The results seemed aligned with other workers who found similar results [44]. The data obtained after

comparing iodine stability over 300 days in common salt iodized with iodate and packed in a 5 kg solid HDPE that iodine concentrations decreased between 910 % of the added iodine within the first month after which values remained practically constant. Raw samples practically lost all the iodine after four weeks of exposure and storage. The losses were proportional with the length of storage. The greatest decrease was seen for samples that were exposed to direct sunlight whiles those stored in the cupboard lost least iodine. In other experiments, in order to find the rate of reduction of iodine stability in iodized salt, the salt samples from different brands were boiled in closed and open vessels at different temperatures. The data showed similar results which was at different boiling temperatures, iodine stability gradually reduced with higher temperatures [45]. These experiments clearly showed that iodine is sensitive to heat. The stability of iodine was also determined by the alkalinity and acidity, not only by temperature. By using a buffer, the different pH values of iodine solution could be analyzed *via* titration to calculate the concentration of iodine in different pH values.

5.3 Radiated Iodine

In most research, the radioactive iodine was used to treat the thyroid disease and followed by examining the morphology of the thyroid. There was a report on gamma irradiations of I_2 vapour in the air which was to investigate the products of the reaction at dose rates of 0.4 to 1.8 $kGyh^{-1}$ [46]. The report showed that a light coloured deposit was observed on the glass irradiation vessel after several days being irradiated. There was also a research on irradiation of gaseous iodine which was exposed to UV radiation. The speciation of gaseous reaction products was measured using Fourier Transform Infra-Red analyser (FTIR).

The size, morphology and elemental composition of particles were also analyzed using Scanning Electron Microscopy coupled with Energy-Dispersive X-ray spectroscopy (SEM-EDX). The formation of reaction products was very fast when gaseous iodine was exposed to UV radiation or ozone. The diameter of the formed iodine oxide particles, measured in the gas phase ranged from dozens to a few hundred of nanometres. The particles were most likely a mixture of I_2O_4 and I_2O_5 [47]. However, for this study, Environmental Scanning Electron Microscopy (ESEM) was used instead of SEM since the sample used was in liquid form. The specimen can be directly examined with ESEM without coating [48].

Energy-dispersive X-ray (EDX) spectroscopy was used for elemental analysis and for chemical composition microanalysis of a sample in conjunction with advanced SEM to provide high-resolution imaging [49]. EDX spectrum showed a plot of how frequently an X-ray is received for each energy level. The peak in a spectrum shows the concentration of the element in the sample. Over the past decade, ESEM images combined with EDX analysis has been extensively used to examine the morphology and elemental chemical composition of wet samples [50].

5.4 Thyroid – iodine Relationship

Iodine deficiency can cause goitre and hypothyroidism due to the low iodine concentration that is unable to produce thyroid hormone [51]. However, if iodine was taken in large amount, it then would cause hyperthyroidism. Usually, the iodine concentration in salt is fixed between 30-100 µg of iodine in one gram of salt. Salt consumption ranges from 5-20 g/day [52]. Meanwhile, the recommended iodization level by [53] is between 40-50 parts per million (ppm). Thus, in this experiment the iodine content in the salt was converted into ppm using the ppm conversion table. This will then be compared with the recommended iodine concentration by WHO. From this, the quantity of iodized salt consumption per day could be controlled so that an adequate amount of

iodine was consumed. Thus, the iodine deficiency that could lead to thyroid disease could be prevented.

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