Volume 6 , No.1 July 2019 p-ISSN: 2147-7736, e-ISSN:2148-3981

Ankara University
Institute of Nuclear Sciences

Journal of Nuclear Sciences

Owner on behalf of Institute of Nuclear Sciences,
Ankara University,
Director

Niyazi MERİÇ, Ph.D.

http://jns.ankara.edu.tr/

Hosted by Ankara University

Journal of Nuclear Sciences

p-ISSN: 2147-7736, e-ISSN:2148-3981

Journal homepage: http:// jns.ankara.edu.tr

DOI: 10.1501/nuclear.2023.48

Destruction of DNA Through Ultraviolet Radiation (UV-C, UV-B, UVA-2, UVA-1) in the Sterilization of Polymer Packaging (ISO: 1043 - PET, LDPE, HDPE) in Fermented Milk Products

V. M. Beluli[1*], A. Kaso[2]

ORCID: 0000-0003-1234-6888,----

[1]Department of Industrial Chemistry, Faculty of Natural Sciences, University of Tirana Boulevard Zogu I, Tirana, Albania
[2]Department of Biology, Faculty of Natural Sciences, University of Tirana, Boulevard Zogu I, Tirana, Albania

Received 04.05.2019; received in revised form 04.09.2019; accepted 11.09.2019

ABSTRACT

Recently UV radiation in the European Union (EU) is being used almost in many industrial aspects and is replacing chemical substances for sterilization. According to ISO 9001 standard, UV sterilization in polymers, being used as packaging in the dairy industry in fermented products is necessary. UV-C radiation within the spectral region (200-280 nm) is the most suitable for creating DNA defects for the purpose of destruction of hydrogen bond and amine bond between pyrimidine bases and the formation of highly stable covalent bonds in DNA. The quality of food products is one of the biggest challenges in food technology. Researchers have been researching in this field to provide a higher quality to food products in the sterilization of packaging (PET, LDPE, HDPE) from microorganisms, according to ISO1043. During this research it is found that the combination of ultraviolet (UV) and hydrogen peroxide (H_2O_2) are the strongest guarantors in the destruction of microorganisms and the formation of major defect in DNA.

Keywords: Ultraviolet, DNA, Hydrogen and Amine bonds, Purine bases, Covalent bonds, Sterilization polymer packing

1. Introduction

The study of ionizing radiation's action on various chemical compounds is a subject of radiation chemistry. Ionizing radiation interacting with the composition it comes in contact with, can cause varied changes but may be either useful or harmful. This effect has been studied quite a lot for different purposes. Currently ionizing radiation has found a widespread use in various fields of science and technology, becoming often an irreplaceable tool in the industry. Ionizing radiation is widely used for sterilization and preservation of various agricultural products, biology, medicine etc. [1], but prolonged exposure to ultraviolet (UV) radiation reveals a well-known problem for polymeric materials [2].

The durability of products and their contact with microorganisms depends on the water content, so the destruction of UV microorganisms is indispensable before the packaged product comes into the market. So, in order to make the most durable food products possible, the first steps in the food conservation industry have occurred the last few decades, by perfecting and providing very well conservation products [3]. One of the main goals of the quality control evaluation is to identify contaminants in raw material, or contamination after a food is processed and before it is placed on the market. During the treatment processes, contamination, both accidentally and economically motivated, can generate incongruence between declared and real composition [4].

*Corresponding author.
E-mail address: valdrin_beluli@hotmail.com, (V.M. Beluli)
Journal of Nuclear Sciences, Vol. 6, No. 1, July 2019, 8-16

ISSN: 2148-7736

Microbiological testing is an important quality management tool in the food industry. Quality management programs aim to prevent contaminations and ensure food safety at the same time. Good hygiene distribution, and pest control, while the hazard analysis and critical control points focus on all steps of practices are mainly focused on facilities, equipment, utensils, employee training, cleaning, sanitation, storage, processing, through monitoring of critical points for contamination and allowing preventive procedures to avoid the hazard [5].

To provide a quality product, we must need to have all the information needed for the polymer used in food technology in packaging. The characteristic of plastic packaging is that it has low cost, it is very manoeuvrable and very elastic. On the other hand, the luck of sterilization causes the main damage of the product, especially in the fermented milk products such as Kos (traditional food from dairy industry) and yogurt. Plastic packaging in polyethylene terephthalate (PET), high density polyethylene (HDPE) and low density polyethylene (LDPE) should be sterilized with UV rays to destroy all microorganisms as UV rays destroy microorganisms' DNA as one of the main factors of the cell, *etc*. Specifically, this research is based on the sterilization of UV-ray plastic packaging for the destruction DNA and permeation of UV-C (200-280) nm, UV-B (280-320) nm, UVA-2 (320-34,0) nm, UVA-1 (340-400) nm, see Figure 1 and Figure 2.

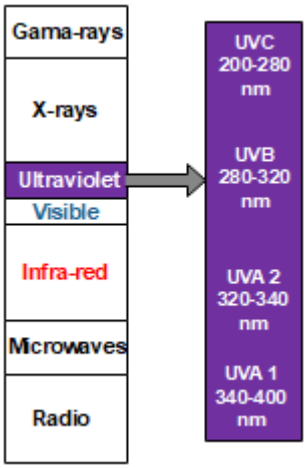

Fig. 1 *UV-ray at wavelengths (200-400) nm*

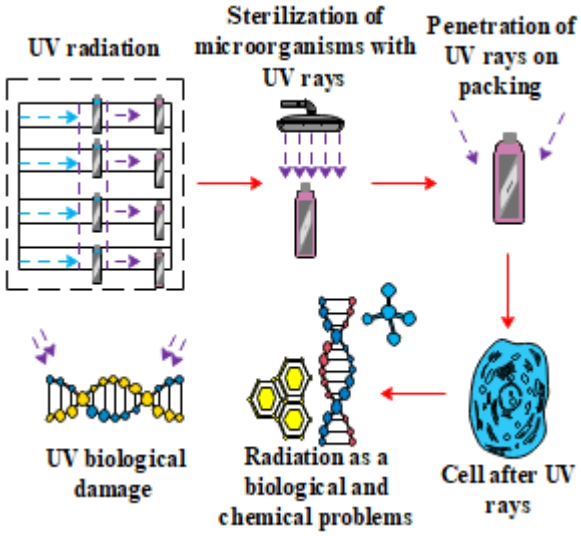

Fig. 2 *Destruction of microorganisms by sterilization with UV-C (200-280) nm*

2. Material and methods

2.1. Germicidal UV-C lamps and food processing

Germicidal UV-C food irradiation uses short wave UV-C light to destroy germs on packaging materials, working surfaces and some foodstuffs. The dairy and bread industries, for example, have seen excellent performance in using our future-oriented technology to extend shelf life and freshness [6].

Sterilization of Non-Foodstuff Surfaces

At all times we have been working with quality standards for radiation packaging complying with ISO 9001: 2015, resulting in the most satisfactory results from this type of research method with internationally recognized standards.

It is aimed to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to customer and applicable statutory and regulatory requirements. [7] Germicidal UV-C lamps are also used to disinfect packaging, filling equipment, conveyor belts, transport containers and working surfaces. Packaging includes lids, cups, sealing and packaging foils for drinks and cool-chain foodstuffs [6].

2.2. UV-sterilized polymers (PET, LDPE, HDPE) packs in the dairy industry

Many new classes of materials have been used to improve different innovative applications [8]. Today, a wide range of plastic materials is produced. These materials have different properties, which depend mainly

on their chemical composition. Assortments made with plastic materials are used in various applications in science [9]. Properties of polymers such as corrosion resistance, light weight, and ease of processing into a variety of shapes can be combined with the unique properties of fillers to form composites with modified appearance, cost, mechanical strength, thermal and electrical conductivity, thermal stability, magnetic characteristics, flame retardant, electromagnetic shielding, dielectric, and barrier properties [10]. HDPE, LDPE, and PP are the most widely used polymers in the world market, employed for electrical equipment, automotive engineering material, and packaging. The most useful properties of PE and PP include oil resistance, rigidity, good stiffness, and thermal stability. Conversely, the utilization of PP and PE is restricted in certain areas owing to some weak properties such as melt viscosity. The weak properties of LDPE include a lack of mechanical and thermal resistance. Hence, numerous researchers are working on improving the properties of LDPE by mixing it with other polymers that have high temperature resistance [11].

Levels 6 and 7 depict 'reservoir centres' (R-centre) and Recent trend of lifestyle changes with less time for consumers to prepare food posed a great challenge in the food packaging sector for the evolution of novel and innovative food packaging techniques [12]. Moreover, the use of radiation is becoming a common treatment to sterilize packages in aseptic processing of foods and pharmaceuticals [13]. The principal roles of food packaging are to protect food products from outside influences and damage, to contain the food, and to provide consumers with ingredient and nutritional information. Traceability, convenience, and tamper indication are secondary functions of increasing importance. The goal of food packaging is to contain food in a cost-effective way that satisfies industry requirements and consumer desires, maintains food safety, and minimizes environmental impact [14].

The simultaneous differential rate equations to be solved Microbiologically sensitive bulk products demand hygienic packaging materials. Practical applications include filling and sealing machines for dairy products and beverages. UV radiation reliably disinfects dairy product cups of various shapes, heat sealing or tubular films, lids and caps or the necks of bottles. Compared to chemical and thermal methods, UV treatment is a very reliable and economically efficient method and can be used in continuous operation on filling lines. UV at wavelengths around 254 nm destroys the DNA of all microorganisms. If used properly, it takes seconds to deactivate viruses and kill microorganisms such as bacteria, yeasts and fungi in an environmentally friendly manner because no extra chemicals are needed. Heraeus Premium UV modules reduce the number of surface germs by up to 99.9 %. The UV lamp is the only consumable. Its service life is rated at 12,000 operating hours or, assuming 24 hours of operation, 2 years of effective use. During that time, the Premium UV module can disinfect about 86 million cups. Breaking down the initial capital expenditure to a single cup would result a lot less than one Euro cent (0.01) per cup [15]. At the main technological point within the industry such as packaging two types of radiation are going to be used: UV-C and UV-B. The UV-C (200-280) nm radius will be used for internal sterilization of the polymer packing, while the UV-B (280-320) nm radiation will be used for internal sterilization of the machine, e.g spaces where plastic bottles are placed. The reason why sterilization of the block for packing is realized is not to have the presence of insects, see Figure 3.

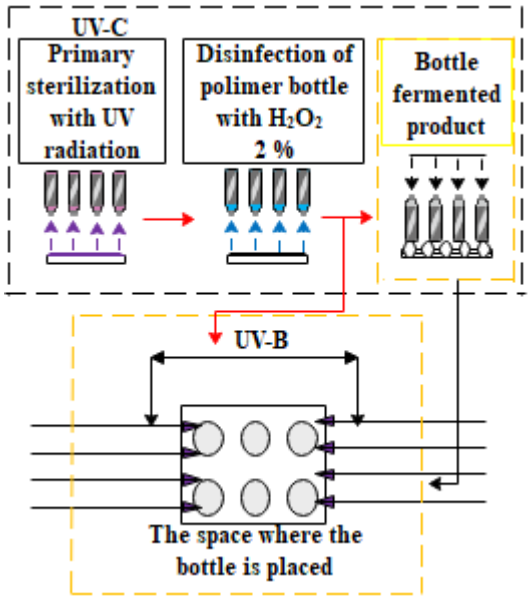

Fig. 3 *Destruction of microorganisms in yogurt bottles with UV-C (200-280) nm and sterilization of the machine block with UV-B (380-320) nm*

2.3. UV radiation before hydrogen peroxide sterilization (H_2O_2) as the main guarantor of post-polymerization packaging

Oxidizing agents, notably hydrogen peroxide (H_2O_2), are increasingly used in a number of medical, food and industrial applications but also in environmental ones such as water treatment [16]. Hydrogen peroxide is responsible for certain bactericidal effects observed in biological systems and killing of invading microorganisms by activated phagocytic cells [17]. H_2O_2 is another strong oxidising agent that dissociates to hydrogen (H^+) and hydroxyl (OH^-) radicals. These oxidative agents readily attack proteins, lipids and

nucleic acids though it is not completely clear how hydrogen peroxide causes cell death [18].

In our case the extermination of microorganisms in the packages used for fermented milk technology will be held by using H_2O_2 as well as by UV sterilization. Why UV should be used before hydrogen peroxide H_2O_2? In order to create a quality product, it is imperative to use both methods for sterilizing the packaging because food quality management for engineers is one of the main issues in the industry, so UV guarantees a longer period for the products in the market, *etc*. However, the combination of UV light and peroxide did lead to major inactivation of glucose 6-phosphate dehydrogenase, an enzyme that was used to monitor the damage to bacterial protein [19] because the quality management of food is one of the main issues in the industry.

2.4. Sterilization by using UV rays aiming the destruction of microorganisms' DNA

Microbial contamination, is one of the main threats to the quality, safety, stability and nutritional value of dairy products [20]. Experimental data as well as theoretical results from several years of research in the area of sterilization methods for effective inactivation of microorganisms on surfaces of packaging materials are compiled and presented in order to choose the right method of sterilization by the food processing industry for a successful operation [21]. UV light cannot penetrate milk and other turbid foods as well, so opaque foods need to be presented to the system as a thin layer. The penetration capacity of the UV light reduces as the absorption coefficient increases. Therefore, it is essential to understand that enhancing the penetrative depth will be beneficial for UV light treatment of foods with higher coefficients of absorption [22].

Although polymer science states that the penetration is not too deep, we have established that UV rays penetrate depending on the material using the following equations that are used to identify UV penetration into the polymer:

$$\alpha = \frac{2 \cdot \pi}{\lambda} \left[\frac{\varepsilon'}{2} \left(\sqrt{1 + \varepsilon''} - 1 \right) \right]^{\frac{1}{2}} \quad (1)$$

$$Z = \frac{\lambda}{2 \cdot \pi} \left[\frac{2}{\varepsilon' \left(\sqrt{1 + \varepsilon''} - 1 \right)} \right]^{\frac{1}{2}} \text{ or } Z = \frac{1}{\alpha} \quad (2)$$

Where α- mitigation factor, Z- depth of penetration, ε' - the dielectric constant of the material, ε''- lost factor and λ- value length.

For the determination of penetration of UV rays into packaging polymers as in our case, it is important to know constant of the dielectric material (ε') and lost factor (ε''), see Table 1.

Table 1. Constanta the dielectric material and lost factor for polymers packing

Polymers	ε'- Constanta the dielectric material	ε''- lost factor
PET	3	0.002
HDPE	2.26	0.00031
LDPE	2.25	0.0002

3. Discussion of Results

Food safety problem is given attention by governments and academics worldwide [23]. Current studies on food safety risk management mainly focus on the security risk sources and performance [24] and the risk in our case is the packaging of the product. Why can packaging be a risk in food technology? From plastic granules that melt to produce plastic tubes to plastic packaging, the packaging is in contact with air microorganisms but may also contain viruses that may be risk to normal metabolism such as humans, so UV sterilization is important to guarantee a quality product for consumers. If we do important scientific research in the field of radiobiology that has application in food technology, we will be more scientifically advantageous to the biologic world of negative character for food quality.

3.1. Detachment of hydrogen bond in DNA with UV

Deoxyribonucleic acid (macromolecule, polynucleotide) is composed of mononucleotides. The polynucleotides are comprised of 1500 to 5,000,000 complexes, which are repeated in succession. In the composition of a nucleotide they participate: purine base (adenine or guanine) or pyrimidine (thymine or cytosine), deoxyribose and phosphoric acid [25].

The hydrogen bond has a special role directly in the existence of the inorganic and organic world as well as in the various phenomena occurring on our planet [26]. Hydrogen bonds are relatively much weaker than the covalent bonds. Another feature of hydrographic connections is that they are stronger when both groups interact and are oriented in order to produce the maximum electrostatic attraction. Hydrogen bonds do not only form water molecules but also other molecules that have a hydrogen bonded to an electronegative atom.

They have a characteristic length of bonds that vary from one type of hydrogen bond to another according to the structural geometry and the distribution of electrons to the molecules that participate in the bond [27].

Couples of nitrogen-based DNA bases stay connected by hydrogen bonds, see Figure 4a. Adenine is coupled with thymine, and guanine with cytosine. Consequently, the number of adenines is the same as the thymine, and that of the guanine with the cytosines [28]. But what is our purpose in the minor science of DNA? Disconnection of UV-C hydrogen bonding is very simple because the hydrodynamic binding energy is very unsteady in comparison to the covalent bond, so we destroy the hydrogen bond and the bond with the amine groups, such as between Adenine and Thymine that creates a very powerful covalent bond between Thymine - Thymine, see the Figure 4b.

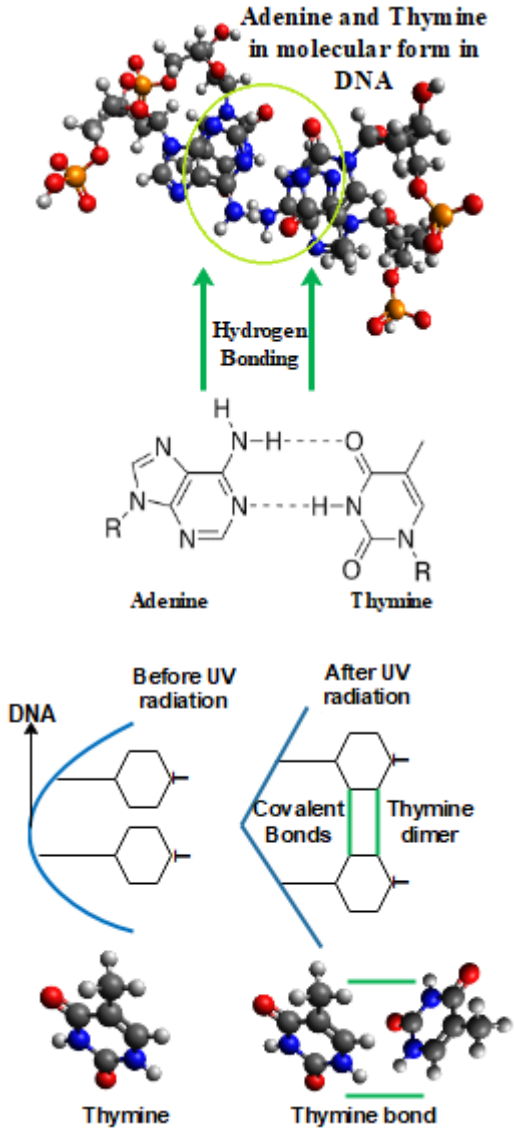

Fig. 4 *Disruption of the hydrogen bond in DNA between the pyrimidine bases (a) and the formation of the covalent bond (b)*

3.2. Penetration and absorption of ultraviolet (UV) in polymers (LDPE, PET and HDPE)

UV light cannot penetrate milk and other turbid foods as well, so opaque foods need to be presented to the system as a thin layer. The penetration capacity of the UV light reduces as the absorption coefficient increases [25]. During our study we have used UV rays with UV-C (200-280) nm, UV-B (280-320) nm, UVA-2 (320-340) nm, UVA-1 (340-400) nm. The radiation of polymers used as packaging in food technology is different, but the most used are PET and LDPE while HDPE is a polymer that is rarely used in food technology. LDPE and PET are used so much in the dairy industry for packing fermented Kos and yogurt. During our study we have noticed that many dairy industry foods such as sterilization of packaging use H_2O_2 to destroy microorganisms. But can it guarantee a H_2O_2 safety in the destruction of microorganisms around 99.5%? This high percentage of H_2O_2 destruction of microorganisms is impossible unless we put UV rays into practice. According to our research, to have a higher quality control than the products obtained, UV radiation should be used in the packaging of LDPE, PET and HDPE before sterilization with H_2O_2. The UV-C (200-280) nm radius in this wave spectrum is easily destroyed eg E. coli, Salmonella and mycoses compared to H_2O_2, see Figure 5 and Table 2.

UV sterilization in the destruction of DNA that microorganisms has advantages and disadvantages:

a. The advantage is that we are creating a good monitoring for sterilization (in polymer packs)
b. And the flaw of this issue is that UV rays penetrate into millimetre units in the polymer, in PET UV penetration (average) is $1.00486 \cdot 10^{-8}$ mm, in LDPE $1.0071 \cdot 10^{-7}$ mm, and in HDPE is $6.48637 \cdot 10^{-8}$ mm.

During our study we have proved that PET polymers are among the most suitable polymers for food technology, because UV penetration in millimetres (mm) is much smaller if compared to LDPE and HDPE, see Figure 6 and Table 2.

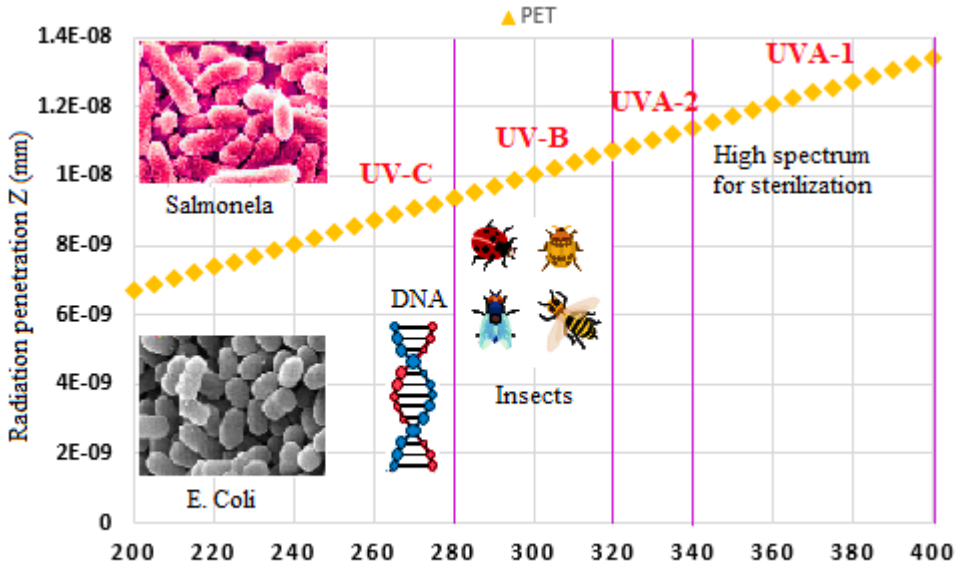

Fig. 5 *Radiation penetration in the PET polymer in the UV-C, UV-B, UVA-2, UVA-1 and destruction of DNA* microorganisms. [abated: salmonella, E. coli. 29, 30]

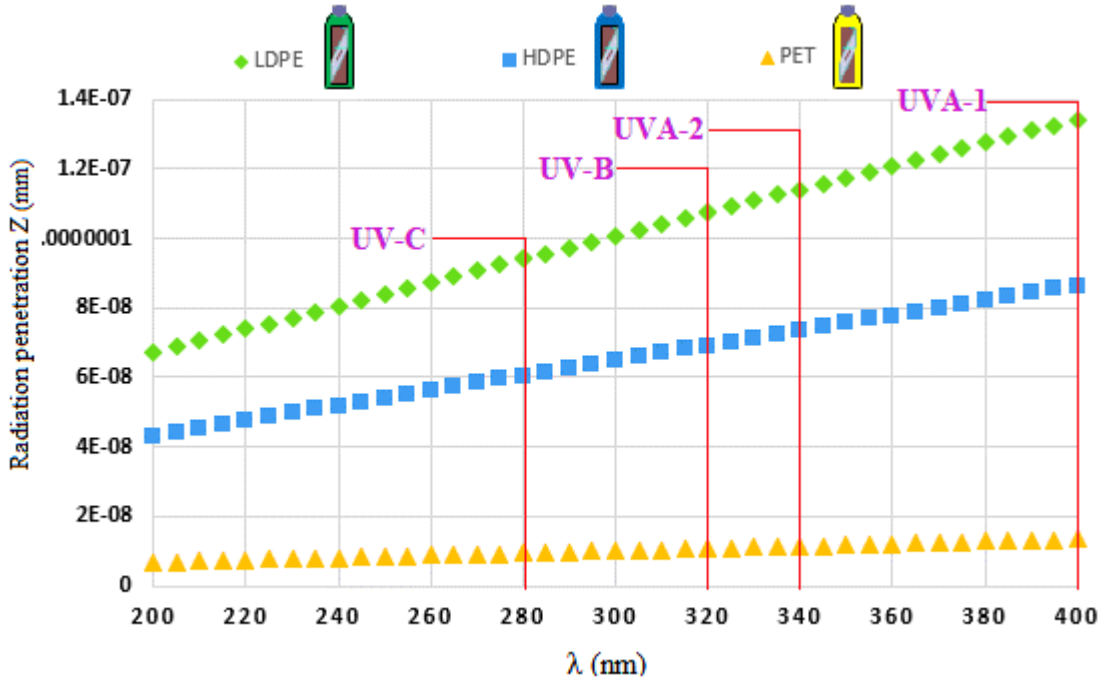

Fig. 6 *UV rays penetration into PET, LDPE and HDPE food packaging*

Table 2. Penetration and absorption of UV in polymers (LDPE, PET and HDPE)

UV	Polymers		PET		LDPE		HDPE	
	λ (nm)	f (Hz)	α (1/cm)	Z (mm)	α (1/cm)	Z (mm)	α (1/cm)	Z (mm)
UV-C	200	$1.50\cdot10^{15}$	$1.49\cdot10^{10}$	$6.7\cdot10^{-9}$	$1.49\cdot10^{9}$	$6.71\cdot10^{-8}$	$2.31\cdot10^{9}$	$4.32\cdot10^{-8}$
	205	$1.46\cdot10^{15}$	$1.46\cdot10^{10}$	$6.87\cdot10^{-9}$	$1.45\cdot10^{9}$	$6.88\cdot10^{-8}$	$2.26\cdot10^{9}$	$4.43\cdot10^{-8}$
	210	$1.43\cdot10^{15}$	$1.42\cdot10^{10}$	$7.03\cdot10^{-9}$	$1.42\cdot10^{9}$	$7.05\cdot10^{-8}$	$2.2\cdot10^{9}$	$4.54\cdot10^{-8}$
	215	$1.40\cdot10^{15}$	$1.39\cdot10^{10}$	$7.20\cdot10^{-9}$	$1.39\cdot10^{9}$	$7.22\cdot10^{-8}$	$2.15\cdot10^{9}$	$4.65\cdot10^{-8}$
	220	$1.36\cdot10^{15}$	$1.36\cdot10^{10}$	$7.37\cdot10^{-9}$	$1.35\cdot10^{9}$	$7.39\cdot10^{-8}$	$2.1\cdot10^{9}$	$4.76\cdot10^{-8}$
	225	$1.33\cdot10^{15}$	$1.33\cdot10^{10}$	$7.54\cdot10^{-9}$	$1.32\cdot10^{9}$	$7.55\cdot10^{-8}$	$2.06\cdot10^{9}$	$4.86\cdot10^{-8}$
	230	$1.30\cdot10^{15}$	$1.30\cdot10^{10}$	$7.70\cdot10^{-9}$	$1.30\cdot10^{9}$	$7.72\cdot10^{-8}$	$2.01\cdot10^{9}$	$4.97\cdot10^{-8}$
	235	$1.28\cdot10^{15}$	$1.27\cdot10^{10}$	$7.87\cdot10^{-9}$	$1.27\cdot10^{9}$	$7.89\cdot10^{-8}$	$1.97\cdot10^{9}$	$5.08\cdot10^{-8}$
	240	$1.25\cdot10^{15}$	$1.24\cdot10^{10}$	$8.04\cdot10^{-9}$	$1.24\cdot10^{9}$	$8.06\cdot10^{-8}$	$1.93\cdot10^{9}$	$5.19\cdot10^{-8}$
	245	$1.22\cdot10^{15}$	$1.22\cdot10^{10}$	$8.21\cdot10^{-9}$	$1.22\cdot10^{9}$	$8.22\cdot10^{-8}$	$1.89\cdot10^{9}$	$5.3\cdot10^{-8}$
	250	$1.20\cdot10^{15}$	$1.19\cdot10^{10}$	$8.37\cdot10^{-9}$	$1.19\cdot10^{9}$	$8.39\cdot10^{-8}$	$1.85\cdot10^{9}$	$5.41\cdot10^{-8}$
	255	$1.18\cdot10^{15}$	$1.17\cdot10^{10}$	$8.54\cdot10^{-9}$	$1.17\cdot10^{9}$	$8.56\cdot10^{-8}$	$1.81\cdot10^{9}$	$5.51\cdot10^{-8}$
	260	$1.15\cdot10^{15}$	$1.15\cdot10^{10}$	$8.71\cdot10^{-9}$	$1.15\cdot10^{9}$	$8.73\cdot10^{-8}$	$1.78\cdot10^{9}$	$5.62\cdot10^{-8}$
	265	$1.13\cdot10^{15}$	$1.13\cdot10^{10}$	$8.88\cdot10^{-9}$	$1.12\cdot10^{9}$	$8.9\cdot10^{-8}$	$1.75\cdot10^{9}$	$5.73\cdot10^{-8}$
	270	$1.11\cdot10^{15}$	$1.11\cdot10^{10}$	$9.04\cdot10^{-9}$	$1.1\cdot10^{9}$	$9.06\cdot10^{-8}$	$1.71\cdot10^{9}$	$5.84\cdot10^{-8}$
	275	$1.09\cdot10^{15}$	$1.09\cdot10^{10}$	$9.21\cdot10^{-9}$	$1.08\cdot10^{9}$	$9.23\cdot10^{-8}$	$1.68\cdot10^{9}$	$5.95\cdot10^{-8}$
	280	$1.07\cdot10^{15}$	$1.07\cdot10^{10}$	$9.38\cdot10^{-9}$	$1.06\cdot10^{9}$	$9.40\cdot10^{-8}$	$1.65\cdot10^{9}$	$6.05\cdot10^{-8}$
UV-B	285	$1.05\cdot10^{15}$	$1.05\cdot10^{10}$	$9.55\cdot10^{-9}$	$1.05\cdot10^{9}$	$9.57\cdot10^{-8}$	$1.62\cdot10^{9}$	$6.16\cdot10^{-8}$
	290	$1.03\cdot10^{15}$	$1.03\cdot10^{10}$	$9.71\cdot10^{-9}$	$1.03\cdot10^{9}$	$9.74\cdot10^{-8}$	$1.59\cdot10^{9}$	$6.27\cdot10^{-8}$
	295	$1.02\cdot10^{15}$	$1.01\cdot10^{10}$	$9.88\cdot10^{-9}$	$1.01\cdot10^{9}$	$9.90\cdot10^{-8}$	$1.57\cdot10^{9}$	$6.38\cdot10^{-8}$
	300	$1\cdot10^{15}$	$9.95\cdot10^{9}$	$1\cdot10^{-8}$	$9.93\cdot10^{9}$	$1.01\cdot10^{-7}$	$1.54\cdot10^{9}$	$6.49\cdot10^{-8}$
	305	$9.84\cdot10^{14}$	$9.79\cdot10^{9}$	$1.02\cdot10^{-8}$	$9.77\cdot10^{8}$	$1.02\cdot10^{-7}$	$1.52\cdot10^{9}$	$6.59\cdot10^{-8}$
	310	$9.68\cdot10^{14}$	$9.63\cdot10^{9}$	$1.04\cdot10^{-8}$	$9.61\cdot10^{8}$	$1.04\cdot10^{-7}$	$1.49\cdot10^{9}$	$6.70\cdot10^{-8}$
	315	$9.52\cdot10^{14}$	$9.48\cdot10^{9}$	$1.06\cdot10^{-8}$	$9.46\cdot10^{8}$	$1.06\cdot10^{-7}$	$1.47\cdot10^{9}$	$6.81\cdot10^{-8}$
	320	$9.37\cdot10^{14}$	$9.33\cdot10^{9}$	$1.07\cdot10^{-8}$	$9.31\cdot10^{8}$	$1.07\cdot10^{-7}$	$1.45\cdot10^{9}$	$6.92\cdot10^{-8}$
UVA-2	325	$9.23\cdot10^{14}$	$9.19\cdot10^{9}$	$1.09\cdot10^{-8}$	$9.17\cdot10^{8}$	$1.09\cdot10^{-7}$	$1.42\cdot10^{9}$	$7.03\cdot10^{-8}$
	330	$9.09\cdot10^{14}$	$9.05\cdot10^{9}$	$1.11\cdot10^{-8}$	$9.03\cdot10^{8}$	$1.11\cdot10^{-7}$	$1.40\cdot10^{9}$	$7.14\cdot10^{-8}$
	335	$8.96\cdot10^{14}$	$8.91\cdot10^{9}$	$1.12\cdot10^{-8}$	$8.89\cdot10^{8}$	$1.12\cdot10^{-7}$	$1.38\cdot10^{9}$	$7.24\cdot10^{-8}$
	340	$8.82\cdot10^{14}$	$8.78\cdot10^{9}$	$1.14\cdot10^{-8}$	$8.76\cdot10^{8}$	$1.14\cdot10^{-7}$	$1.36\cdot10^{9}$	$7.35\cdot10^{-8}$
UVA-1	345	$8.70\cdot10^{14}$	$8.65\cdot10^{9}$	$1.16\cdot10^{-8}$	$8.63\cdot10^{8}$	$1.16\cdot10^{-7}$	$1.34\cdot10^{9}$	$7.46\cdot10^{-8}$
	350	$8.57\cdot10^{14}$	$8.53\cdot10^{9}$	$1.17\cdot10^{-8}$	$8.51\cdot10^{8}$	$1.17\cdot10^{-7}$	$1.32\cdot10^{9}$	$7.57\cdot10^{-8}$
	355	$8.45\cdot10^{14}$	$8.41\cdot10^{9}$	$1.19\cdot10^{-8}$	$8.39\cdot10^{8}$	$1.19\cdot10^{-7}$	$1.30\cdot10^{9}$	$7.68\cdot10^{-8}$
	360	$8.33\cdot10^{14}$	$8.29\cdot10^{9}$	$1.21\cdot10^{-8}$	$8.27\cdot10^{8}$	$1.21\cdot10^{-7}$	$1.28\cdot10^{9}$	$7.78\cdot10^{-8}$
	365	$8.22\cdot10^{14}$	$8.18\cdot10^{9}$	$1.22\cdot10^{-8}$	$8.16\cdot10^{8}$	$1.23\cdot10^{-7}$	$1.27\cdot10^{9}$	$7.89\cdot10^{-8}$
	370	$8.11\cdot10^{14}$	$8.07\cdot10^{9}$	$1.24\cdot10^{-8}$	$8.05\cdot10^{8}$	$1.24\cdot10^{-7}$	$1.25\cdot10^{9}$	$8\cdot10^{-8}$
	375	$8\cdot10^{14}$	$7.96\cdot10^{9}$	$1.26\cdot10^{-8}$	$7.94\cdot10^{8}$	$1.26\cdot10^{-7}$	$1.23\cdot10^{9}$	$8.11\cdot10^{-8}$
	380	$7.89\cdot10^{14}$	$7.86\cdot10^{9}$	$1.27\cdot10^{-8}$	$7.84\cdot10^{8}$	$1.28\cdot10^{-7}$	$1.22\cdot10^{9}$	$8.22\cdot10^{-8}$
	385	$7.79\cdot10^{14}$	$7.75\cdot10^{9}$	$1.29\cdot10^{-8}$	$7.74\cdot10^{8}$	$1.29\cdot10^{-7}$	$1.20\cdot10^{9}$	$8.32\cdot10^{-8}$
	390	$7.69\cdot10^{14}$	$7.66\cdot10^{9}$	$1.31\cdot10^{-8}$	$7.64\cdot10^{8}$	$1.31\cdot10^{-7}$	$1.19\cdot10^{9}$	$8.43\cdot10^{-8}$
	395	$7.59\cdot10^{14}$	$7.56\cdot10^{9}$	$1.32\cdot10^{-8}$	$7.54\cdot10^{8}$	$1.33\cdot10^{-7}$	$1.17\cdot10^{9}$	$8.54\cdot10^{-8}$
	400	$7.5\cdot10^{14}$	$7.46\cdot10^{9}$	$1.34\cdot10^{-8}$	$7.45\cdot10^{8}$	$1.34\cdot10^{-7}$	$1.16\cdot10^{9}$	$8.65\cdot10^{-8}$

4. Conclusion

The purpose of this research is to understand whether the hydrogen bonding of DNA to the pyrimidine bases and the formation of a strong covalent bond between the pyridine bases is destroyable using UV radiation. UV rays can guarantee a powerful sterilization in the destruction of the microorganisms that are directly transmitted to the DNA by defect in between hydrogen bonds and bonding to the amine groups.

Applying the best quality standards in a food industry remains a challenge for future engineers as to what kind of plastic packaging should be used if the advanced UV sterilization technique increases. UV radiation is a good solution for the sterilization of polymer packages but we need to be well informed about what types of packaging should be used in different UV radiation spectra. In our case we have achieved sufficient results in four different UV spectra to monitor the penetration of UV rays into the packaging.

UV-C (200-280 nm) is the most suitable spectral region for destroying microorganisms; these spectra types have also been verified by scientists that DNA cannot resist this value length and forces the hydrodynamic boding to break off very easily, forming covalent bonds as the lasting bond that exists in the molecular aspect, both in chemistry and biology. UV-B, UVA-1 and UVA-2 cause greater millimetre penetration (mm) compared to UV-C. Based on our research, it is related to the polymers used as packaging in the food industry with the PET suitable, although it is under the influence of UV radiation; the penetration of the radiation is much lower compared to LDPE and HDPE where the average value of PET penetration is $1.00486 \cdot 10^{-8}$ mm, UV penetration in LDPE is $1.0071 \cdot 10^{-7}$ mm and HDPE is $6.48637 \cdot 10^{-8}$ mm.

In the Republic of Kosovo, the use of UV in sterilization technology is very limited, the main reason being the financial cost. In this research, we have suggested that any food industry after placing the produced foodstuff should first sterilize the packaging of UV-C food, then begin to place the product on the packaging. Our scientific research has concluded that the non-use of UV-C rays in damaging DNA that the microorganisms cannot guarantee to any industry for a high quality and that UV rays should definitely be placed at the critical points of control in food technology.

Conflict of Interest

The authors have no conflict of interest.

References

[1]. S. Malja, F. Hasani, B. Daci. “Radiokimia”, Prishtinë, pp. 219, 243, (2014).

[2]. M. Oliviero, M. Stanzione, M. D’Auria, L. Sorrentino, S. Iannace, L. Verdolotti. “Vegetable Tannin as a Sustainable UV Stabilizer for Polyurethane Foams, Polymers 11(3):480, (2019).

[3]. R. Troja. “Kimia dhe Teknologjia Ushqimore”, Universiteti i Tiranës, Tiranë, pp. 7, 92, 258, (2001).

[4]. A. Bruno, A. Sandionigi, G. Agostinetto, L. Bernabovi, J. Frigerio, M. Casiraghi, M. Labra, “Food Tracking Perspective: DNA Metabarcoding to Identify Plant Composition in Complex and Processed Food Products”, Genes. 10(3):248. (2019).

[5]. A. C. Camargo, M.V.C. Cossi, W.P. Silva, L. S. Bersot, M. Landgraf, J. Baranyi, B.D. Franco, N. L. Augusto. “Microbiological Testing for the Proper Assessment of the Hygiene Status of Beef Carcasses”, Microorganisms, 7(3):86, (2019).

[6].https://www.light-sources.com/solutions/germicidal-uvc-lamps/. (04.09.2019)

[7].https://www.iso.org/standard/62085.html. (06.09.2019)

[8]. Ş. Şenol, E. Akyol. “Study on the preparation and drug release property of Modified PEG-DA based hydrogels”. Journal of the Turkish Chemical Society, Section A: Chemistry, 6 (1), 1-14, (2019).

[9]. S. Drushku, E. Liqo. “Materialet Plastike”, Universiteti i Tiranës, Tiranë, p. 179, (2016).

[10]. P. Sormunen, T. Kärki. “Compression Molded Thermoplastic Composites Entirely Made of Recycled Materials”, Sustainability. 11(3):631, (2019).

[11]. S.Z. Ahmed Dabbak, H.A. Illias, B.C. Ang, N.A. Abdul Latiff, M.ZH. Makmud. “Electrical Properties of Polyethylene/Polypropylene Compounds for High-Voltage Insulation”, Energies. 11(6):1448, (2018).

[12]. I. Majid, G. Ahmad, N. Shuaib Mohammad, D. Vikas Nanda. “Novel food packaging technologies”, Innovations and future prospective, Journal of the Saudi Society of Agricultural Sciences. 17 (4): 454-462, (2018).

[13]. B. Ozen, J. D. Floros. “Effects of food processing techniques of packaging materials”, Trends in Food Science & Technology) 12(2):60-67, (2001).

[14]. K. S. Marsh, B. Bugusu T. Tarver, "Food packaging and its environmental impact", Food Technology, 61(4):46-50, (2007).

[15]http://www.cosmouv.co.nz/site/cosmographics/files//Heraeus%20Premium%20Module.pdf (21.04.2019)

[16]. E. Linley, S. P. Denyer, G. McDonnel, C. Simons, J.Y. Maillard, "Use of hydrogen peroxide as a biocide: new consideration of its mechanisms of biocidal action", Journal of Antimicrobial Chemotherapy, 67 (7): 1589–1596, (2012).

[17]. B.J. Juven, M. D. Pierson. "Antibacterial Effects of Hydrogen Peroxide and Methods for Its Detection and Quantitation", Journal of Food Protection:. 59(11):1233-1241, (1996).

[18]. R. Lacey, G. Walker. "Provision and control of water for healthcare purposes", Decontamination in Hospitals and Healthcare, 254-298, (2014).

[19]. J.S. Reidmiller, J.D. Baldeck, G.C. Rutherford, R.E. Marquis. "Characterization of UV-peroxide killing of bacterial spores", Journal Food Protection, 66(7):1233-40, (2003).

[20]. I. Ostrov, T. Paz, M. Shemesh, "Robust Biofilm-Forming Bacillus Isolates from the Dairy Environment Demonstrate an Enhanced Resistance to Cleaning-in-Place Procedures", Foods. 8(4):134. (2019).

[21]. I.A. Ansari MD, A.K. Datta. "An Overview of Sterilization Methods for Packaging Materials Used in Aseptic Packaging Systems", Food and Bioproducts Processing,81(1): 57-65 (2003).

[22]. R. Choudhary, S. Bandla, "Ultraviolet Pasteurization for Food Industry", International Journal of Food Science and Nutrition Engineering, 2(1): 12-15 (2012)

[23]. T. Chen, L.Wang, J. Wang, Q. Yang. "A Network Diffusion Model of Food Safety Scare Behavior considering Information Transparency", Complexity, 1-16 (2017).

[24]. T. Chen, S. Wang, L. Pei, J. Wang. "Assessment of Dairy Product Safety Supervision in Sales Link: A Fuzzy-ANP Comprehensive Evaluation Method". Journal of Food Quality. 1-16 (2018).

[25]. M. Plakolli. "Mikrobiologjia e Përgjithshme", Universiteti i Prishtinës, Kosovë, p. 47, (2001)

[26]. B. Kamberi. "Bazat Teorike së Kimisë të Përgjithshme dhe Inorganike", Universiteti i Prishtinës, Prishtinë, p. 357, (1997).

[27]. A. Trebicka. "Biokimia", Universiteti i Tiranës, Tiranë, p. 11, (2012).

[28]. A.G. Bacu. "Baza të Bioteknologjisë Molekulare", Universiteti i Tiranës, pp. 23, 24, (2018).

[29].https://fineartamerica.com/featured/2-salmonella-bacteria-sem-.html (23.04.2019)

[30].https://en.wikipedia.org/wiki/Escherichia_coli_O157:H7 (23.04.2019)