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RAMAN SPECTROSCOPIC INVESTIGATION OF THE EFFECT OF ELECTRICAL STIMULATION ON DESTROYING LIPID MEMBRANE OF VIRUSES

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ABSTRACT

In this study, the destruction of the lipid membrane of viruses by electrical simulation was investigated by molecular modeling. Since it is well known that soap directly attacks the virus by disrupting its the lipid bilayer membrane, the formation of soap by electrical simulations of human body fluids were modeled, using saline and oil added saline solutions. Oil was used as a model for lipid membrane and molecular structural alterations were followed by using Raman spectroscopy. The results indicated that when electrical simulations were performed by using square wave dc current 10V for 10 m duration, the acidic saline environment converted to basic environment, which destroyed the added oil by formation of soap.

Keywords :Economy; Viruses; Lipid; Electrical Stimulation; Molecular Modeling; Raman Spectroscopy
JEL-Classification: I10, C0

VİRÜSLERİN LİPİT ZARININ YOK EDİLMESİ ÜZERİNE ELEKTRİKSEL UYARIMIN ETKİSİNİN RAMAN SPEKTROSKOPİK İNCELENMESİ

ÖZET

Bu çalışmada, elektriksel simülasyon ile virüslerin lipid zarının yok edilmesi moleküler modelleme ile incelenmiştir. Sabunun, virüsün lipit çift tabakalı zarını bozarak doğrudan saldırdığı iyi bilindiğinden, insan vücut sıvılarının elektriksel simülasyonları ile sabun oluşumu, salin ve yağ ilaveli salin solüsyonları kullanılarak modellenmiştir. Yağ, lipid zarı için bir model olarak kullanılmış ve moleküler yapısal değişiklikler, Raman spektroskopisi kullanılarak izlenmiştir.Sonuçlar, 10 dak. süresince kare dalga dc akım 10V kullanılarak elektrik simülasyonları yapıldığında, asidik salin ortamın bazik ortama dönüştüğü ve sabun oluşturarak eklenen yağı yok ettiğini göstermiştir.

Anahtar Kelimeler: Ekonomi; Virüsler; Lipid; Elektriksel Uyarım; Moleküler Modelleme; Raman Spektroskopisi
JEL-Sınıflama: I10, C0

1. INTRODUCTION

The World Health Organization stated that as of 08.09.2020, more than 27.4 million corona virus cases were detected in the world and more than 900 thousand lives were lost. Consequently, there has been a decrease in production and global demand has decreased.

Increases in commodity prices and the fall in consumer demand caused a contraction in value added. Narrowing in demand, cancellation of orders, stopping production activities of companies, and negativities and breaks in logistics, transportation and tourism sectors have affected employment and caused great losses in the workforce.

The OECD estimate is that the world-wide unemployment rate will be around 10 percent. Nearly 500 thousand workers have already lost their jobs. International organizations predict that the world economy will shrink substantially.

For example, the IMF stated that the economies of developed countries will shrink by 8.8 percent and that of the Developing Countries by 3.0 percent. The OECD and World Bank estimate that the downsizing will be even greater.

The contraction in the World Trade Volume is even greater. While Developed Countries shrank by 13.4 percent, it is estimated that the shrinkage of Developing Countries will be around 10 percent.

Many important studies are still being done and have been carried out on virus treatments that can affect the whole world. In the study conducted by Mizuno et al. (1990), it was reported that, Swine Vesicular Disease Virus (SVDV) and Equine Herpesvirus-l (EHV-1) in liquid can be inactivated effectively by the pulsed high electric field of 30 kV/cm crest value for 60 to 120 times, (the input electrical energy of 43.6 to 872 cal/cc). In this study, the core of viruses containing DNA or RNA was shown to be damaged after application of electric field, by electron microscopy.

With a study conducted by Kumagai et al. (2007), the effects of electrical stimulation on HIV-1-adsorbed MAGIC-5 (MAGIC-5/HIV-1) cells were investigated. It was shown that the HIV-1 infectivity of the MAGIC-5 cells was prevented with constant d.c. potential of 1.0 V application for 5 minutes (Kumagai et al., 2007).

In another study on the investigation of the effects of high-frequency electric currents on biological objects (Nyrop, 1946), it was reported that when *Bac. coli* in a liquid medium was treated with the modulated current, with strength of 230 V/cm, 99.5 per cent of the bacteria were killed.

Thanks to modern science and computer technology, the electrotherapy has reached the level of development, as a relatively safe and effective application that can be applied in pain, movement disorders, epilepsy, Tourette's syndrome, psychiatric disease, addiction, urinary incontinence, impotence, infertility, respiratory paralysis, tinnitus, blindness and in various nervous system diseases (Fodstad et al., 2007). In another study, it was reported that by application of electric pulses, induced changes in tumour blood flow occured (Parkins et al., 1999).

The electrolyzed products of sodium chloride solution were examined for their disinfection potential against hepatitis B virus (HBV) and human immunodeficiency virus (HIV) in vitro by Morita et al (2000). In this study, the electrolyzed solution, contained 4.2 ppm of free chlorine, showed to have greater efficacy against HBsAg and HIV1 than sodium hypochlorite. The disinfective effects was proposed being primarily due to the free chlorine content but also by some other factors present in the electrolyzed solution could be effective.

In the study conducted by Kasai et al. (2000), the bactericidal and virucidal effects of hypochlorite produced by electrolysis of salt water were investigated for pathogenic bacteria and viruses of fish. It was fould that hypochlorite produced by electrolysis of salt water (3.5 m^3/h, 0.1 A) was much more effective than those of chemical regeant hypochlorite.

The experimental results in the study of Gluhchev et al. (2015) proved the strong effect of different types of electrochemically activated water solutions (catholyte / anolyte) on various microbes and viruses.

In this study in order to investigate to destroy the membrane of viruses by electrical simulation, electrolyzed solutions of saline and olive oil added saline were investigated by Raman spectroscopy. Since it is well known that soap directly attacks the virus by disrupting the lipid bilayer membrane of the virus, the formation of soap by electrical simulation of human body fluids were modeled, using saline and oil added saline solutions.

2. EXPERIMENTAL DETAILS

For the experiment commercial saline solution (isotonic serum containing 0.9 % sodium chloride solution) was used. Olive oil was used to model soap formation in saline solution to disrupt the membrane of the virus by electrical simulations. For electrical simulations square wave dc current 10V was used for 10 m. The electrolysis the saline solution was carried out using steel electrodes at 10 volts, 300 Hz and 10 m electrolysis time was applied.

Micro Raman spectra of saline solution before and after electrolysis and after adding olive oil were recorded by a JascoNRS 3100 micro Raman spectrometer (1200 lines/mm grating and high sensitivity cooled CCD) equipped with a 532 nm diode laser. Rayleigh scattering was rejected by a notch filter.

The spectrometer was calibrated with the silicon phonon mode at 520 cm^{-1}. The exposure time and the accumulation were taken 2 s, 50 spectra, respectively. A 50 μl sample drop was placed onto an alumina support for Raman analysis. The spectrum of the alumina substrate was subsequently subtracted.

3. RESULTS AND DISCUSSION

In **Figures 1** and **2**, the micro Raman spectra of the of saline solutions are shown comparatively before the electrolysis, after the electrolysis and after electrolysis of the oil added solution for 10 m.

For all spectra were recorded with the same amount of sample (50 µl sample drop), and no normalization presedure was applied. The original saline solution (**Figure 1a**) has weak intense OH stretching bands at 3413 and 3255 cm^{-1} due to water. However, after electrolysis of the saline solution, the OH stretching bands increased dramatically and a shoulder at 3587 cm^{-1} is appear which indicated NaOH formation.

Moreover an oil drop was added to the electrolyzed solution, and after repeating of electrolysis 10 minutes, the Raman spectrum was recorded and the intensities of the OH stretching bands were found to decrease dramatically due to soap formation, which confirms NaOH formation of electrolyzed solutions of saline.

Studies in the literature show that besides intramolecular O-H pairs, intermolecular O-H bonded by hydrogen bonds contribute to O-H stretching. The flexibility of this bond is sensitive to temperature (Beccucci et al., 1999) and the presence of ions. Studying this spectral region can be used to determine the water phase or to detect dissolvedions in water (Durickovic, 2016).

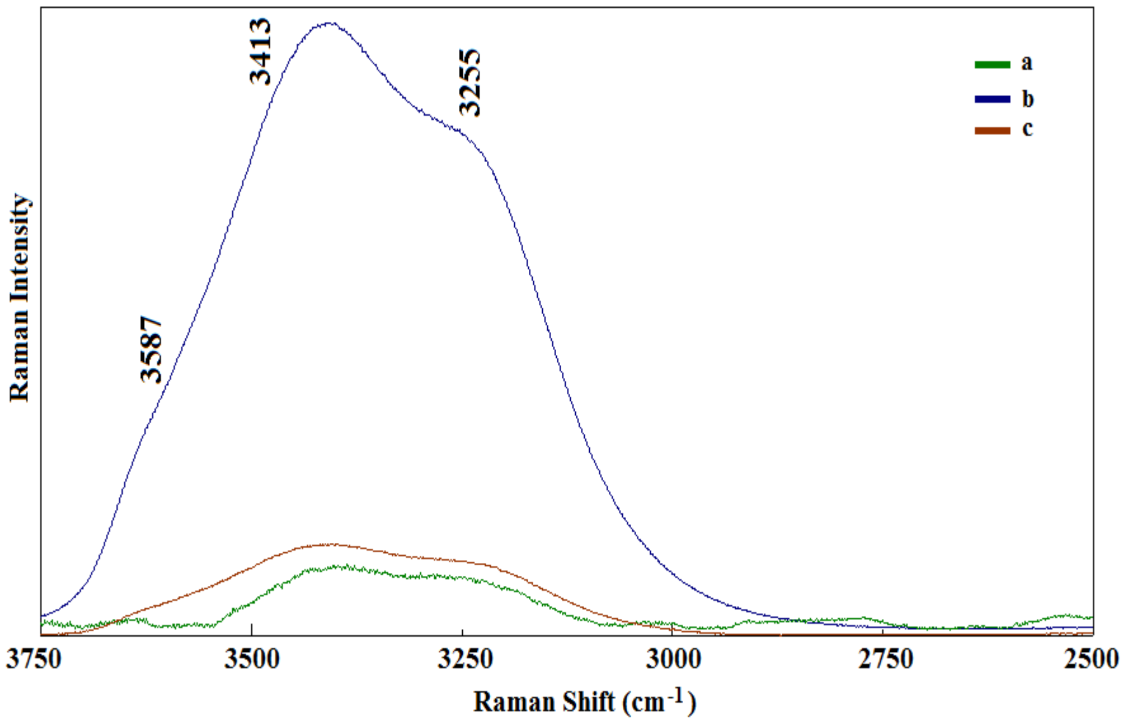

Figure 1. The 3750- 2500 cm^{-1} region of the micro Raman spectrum of the saline solutions, before any treatment (a), after electrolysis (b) and after adding olive oil to the solution after electrolysis (on solution after the electrolysis one drop oil was added and waited for 10 minutes.)

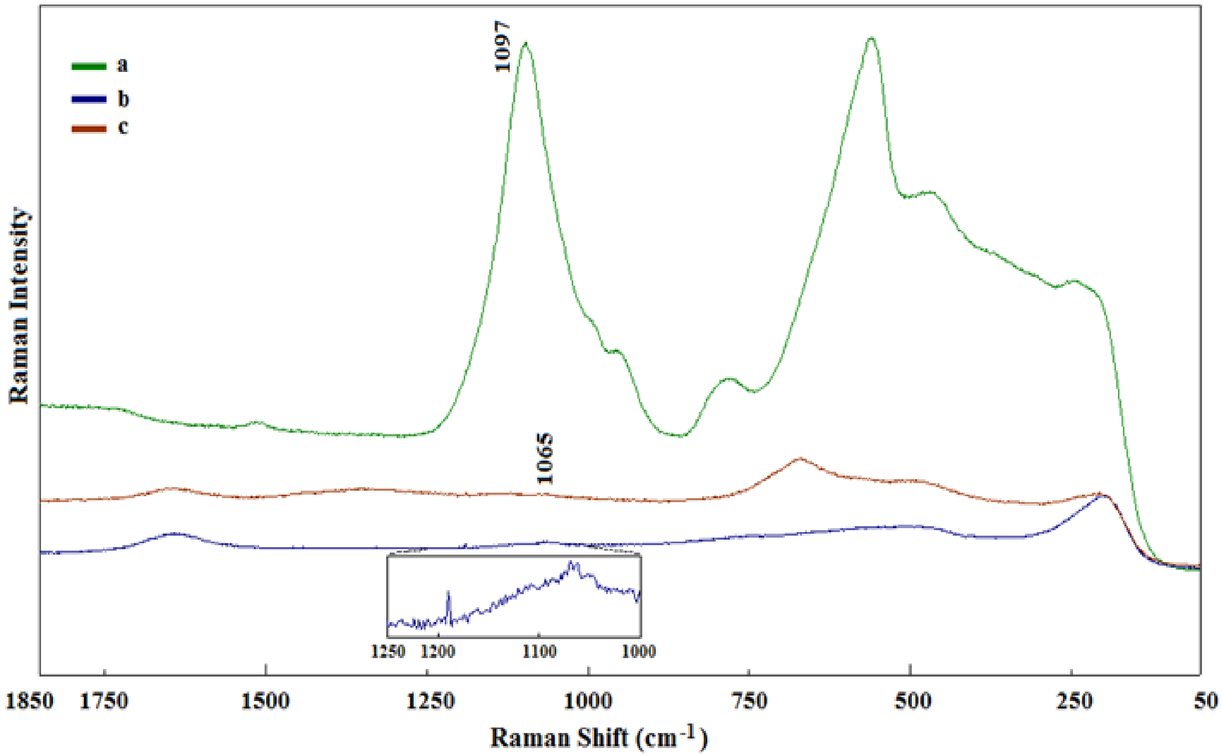

Figure 2. 1850- 50 cm^{-1} region of the micro Raman spectrum of the saline solutions, before any treatment (a), after electrolysis (b) and after electrolysis of 10 m, of the oil added solution (c).

Commercial saline solution has a pH of 5.5 (mainly due to dissolved carbon dioxide) making it acidic (Reddi, 2013). Raman spectral result indicates that when the electrolysis process is applied to saline solution, the acidic environment turns into a basic environment. The C-OH stretching vibration of the carbonic acid (Falcke et al., 1990) observed in untreated saline solution was observed at 1097 cm^{-1} decreased drastically after electrolysis of the saline (See **Figure 2b**). However $NaHCO_3$ peak around 1065 cm^{-1} appears.

4. CONCLUSIONS

Affecting employment, demand shrinkage, cancellation of orders, stopping production activities of companies, negativities and breaks in logistics, transportation, tourism sectors, etc., the virus has affected the world from all areas. In this study the destruction of the lipid membrane of viruses by electrical simulation was investigated by molecular modeling.

The alterations observed in Raman spectra of untreated saline and electrical simulation applied saline, indicate that the environment has changed from an acidic environment to a basic environment by applications of electrical simulations.

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