**“In the name of God”**

**Abstract**

In this project, we first examine the effect of nanoparticle size on the characteristics of localized surface plasmon resonance (LSPR) and find a model to predict LSPR behavior according to the size parameter and try to optimize it. In the following, we review the research conducted to diagnose severe acute respiratory syndrome coronavirus using LSPR properties. It should be noted that this method has replaced the old methods that had errors that could not be neglected at the beginning of the disease.

**Part I)**

Metal nanostructures are increasingly used due to their practical properties. One of their unique characteristics is local surface plasmon resonance. Due to the high density of free electrons, metals are the best producers of plasmons. Surface plasmon resonance is the excitation of electrons in the region near the metal surface. Also, the surface plasmon resonance of a particle whose size is smaller than the wavelength of light is called local surface plasmon resonance. More precisely, in this case, the ratio of the radius of the metal particle to the wavelength (R/λ) is less than 0.1. According to Mie's theory, local surface plasmon resonance is dependent on five factors, size, shape, composition of nanoparticles, distance between particles and refractive index of the surrounding environment of nanoparticles, which in the rest of the report, we will look at the effect of size and predict its behavior. the payment. According to Mie's theory, the light that shines on the nanoparticle solution is divided into two parts, transmitted light and scattered light, and in other words, the absorbed light part is equal to the difference between transmitted light and scattered light. If the radius of spherical nanoparticles is much smaller than the wavelength of light, the magnitude of scattered light will be proportional to R6 and the magnitude of absorbed light will be proportional to R3. So it can be concluded that the larger the size of the nanoparticle, the more the particles tend to scatter light. If light with a wavelength of λ is irradiated to nanoparticles, if the radius of the nanoparticle is less than 20 nm, the nanoparticles tend to pass through the light and ultraviolet-visible spectroscopy will be suitable for this state, and in the case that their radius is greater If it is 20 nm, the tendency to scatter light will increase and the use of Raman spectroscopy is more reasonable [1].

Gold and silver are the main nanoparticles used in LSPR. Each of the parameters of size, uniformity, shape, dispersion and concentration change slowly, causing a change in the wavelength. In terms of size, increasing the size of the nanoparticle results in longer wavelengths (red shift). On the other hand, by reducing the size of the nanoparticle, a shorter wavelength is obtained (blue shift). Refractive sensitivity index (RIS) is used to measure changes in wavelength. Navas et al. investigated that by increasing the size of silver and gold nanoparticles from 5 to 50 nm, the refractive index increased by 122 nm/RIU and 105 nm/RIU, respectively [2]. Shabani-Nejad and Ramakrishna theoretically found that with increasing nanoparticle size, aspect ratio and plasmonic sensitivity increased [3].

**Part II)**

The method that is commonly used in the diagnosis of corona today is polymerase chain reaction with reverse transcription. Of course, this method has errors in diagnosis at the beginning of the disease, and at the same time, it is considered a time-consuming method. In order to solve this problem, finding new and more efficient methods has become one of the main concerns of researchers. In this regard, methods based on biological sensors were proposed as an ideal option to replace old methods such as CT Scan or RT-PCR [4]. Among the various biosensors, biosensors that operate based on LSPR are suitable for various applications, especially medical diagnostics, and their lack of need for fluorescence labels (Label Free) makes them an attractive option. Terry has also changed. [5]. The use of nanoparticles in the system of biological sensors plays a very important role in improving their performance. The reason for the high efficiency of this type of sensors is the strengthening of the plasmonic field around the nanoparticles. Worp and colleagues used the property of surface plasmon resonance to determine the bio-physical properties of SARS-CoV-2 [6]. In another study, Q and colleagues used a type of dual-purpose biosensor to diagnose corona disease. This biosensor is a combination of photothermal plasmon and localized surface plasmon resonance spectroscopy. This group used gold nano-islands that were modified with DNA receptors. These modified nanoislands have a high sensitivity to detect the sequence of sever acute respiratory syndrome. This efficiency of gold nano-islands has emerged through nucleic acid hybridization. In order to increase the sensitivity for disease diagnosis, the heat generated by the conduction layer electrons (at the plasmonic resonance frequency) is applied to the gold nano-island chip. This generated heat increases the energy level of gold nano-islands, and these energy-rich nano-islands become a factor in increasing the hybridization temperature, thereby facilitating the process of accurate differentiation between two similar gene sequences. The dual-purpose biosensor used in this research showed a high sensitivity against the sequence of sever acute respiratory syndrome, so that even up to 0.22 pM concentration, it will be able to detect the disease, which shows the high sensitivity of this method in low concentrations. has [7]. Figure 1.a shows the schematic view and Figure 1.b shows the laboratory view of this method.

In another study, Hong et al. used a nanoplasmonic biosensor to study the detection of SARS-CoV-2 without the need for sample preparation. For this purpose, they used Au-TiO2-Au nanocups. Using the transmitted light spectroscopy method, they determined the values of the plasmonic resonance wavelength as well as the intensity of the virus shown by the sensor [8].

In some researches, gold nanoparticles have been used in the structure of biological sensors that are designed based on the plasmonic resonance feature, which have the ability to quickly and single-step detect the corona virus. In this method, in order to identify the virus, the binding between SARS-CoV-2 mAbs and SARS-CoV-2 spike protein, as well as the binding between gold nanoparticles and the regions of the binding receptor is performed [9].

**Conclusions**

The LSPR feature is a very useful feature, especially for metals such as silver and gold, and it appears when the ratio of radius to wavelength is low. With the increase in the size of metal nanoparticles, the tendency for light to pass through the nanoparticle increases, while with the decrease in the size of nanoparticles, the tendency for light scattering increases. By increasing the size of nanoparticles, a red shift is created, and on the contrary, by decreasing the size, a blue shift is created. Also, the refractive index increases with the increase in nanoparticle size. Therefore, according to the intended application, the size of the nanoparticle should be determined. The LSPR feature of nanoparticles can be used in biological sensors as well, and based on this, biological sensors have the ability to replace today's common methods, which are sometimes time-consuming and sometimes associated with errors, and significantly reduce the amount of errors. and even in low concentrations, they are able to diagnose severe acute respiratory syndrome. These biosensors do not need to be labeled and this factor has made them a more attractive option. Also, in some studies, these sensors did not require sample preparation.

**References**

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