A Simple & Low Cost Method for Preparation and Characterization of Photosensitive Holographic Film for the Application of Biosensor for Medical Diagnosis

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Abstract— In the last decade development of holographic sensors have been taken great attention to the scientists due to its application in different field like medicine, food, aviation petrol, bank notes As an example this type of sensors are used to detect the change in pH level and temperature due the metabolism of the body, a variety of enzymes, bacterial cells and physical stimuli. An attempt has been made by using a highly absorbent material i.e. hydrogel which is impregnated by tiny silver particles with the help of laser pulse to develop a low cost holographic sensor film to detect the presence of drugs, alcohol, sugar in urine as a preliminary information for the patients such that they can consult with the doctor in time.

Key words: Hologram, Hydrogel, Stimuli, p-HEMA

I. INTRODUCTION

Holography is a technique in which three dimensional image of the object is recorded by using suitable Laser source .Nowadays holograms are used to recognize the genuineness of the product ranging from medicine, food to aviation petrol. Holograms are also unavoidable to design bank notes, credit cards etc. which prevents them from their counterfeit products. With the help of hologram technology it is possible to get original medicine in the market for our treatment. Also it protects us of using duplicate bank notes. Nowadays smart hologram sensors can also used for medical diagnosis to detect the presence of glucose, alcohol in urine. In this process we are applying the principle of Physics to design the biosensor for medical diagnosis. At present this is a most challenging work for the researcher. The property of hologram which respond to physical, chemical and biological stimuli are providing a new tool for diagnostic tests [1-5]. Hologram also underpins supermarket scanners; it can even be used to store three dimensional optical data.

Diagnostic tests are common in the modern world are being used to assess everything from illness to food safety, from security to bioterrorism. Currently these tasks are carried out by measuring several chemical or biological parameters in readily assessable samples and then sending them to a central laboratory for analysis. Although such laboratories often fully automated and do not even require the Expertise or Scientist or Doctor. It can still take several days before the results are returned which make a delay that can hamper the diagnosis of the patient.

Medical diagnostics have witnessed a revolution in recent years with an increase in medical tests for patients day by day. For example the time required for tests for cardiac problems are reduced from days to minutes in a medical diagnostic centre. Similar trends are apparent in water quality monitoring, food and beverage assurance in military and antiterrorism testing. Such point of sampling tests can also reduce the cost per test by more than a third, together with additional savings in manpower. Since testing is often performed on the ground by technical staffs and required immediate interpretation by the experts, it would be beneficial for the patients to utilize the following technology as this is robust and accurate.

Sensors based smart holograms, the optical properties for which change in response to external stimuli, are ideally suited for diagnostic testing. In addition to providing simple and reliable sensors with built in read out capabilities, such holograms are commercially viable because they can be made using established techniques. But they are costly because of single use only.

Smart holograms are noble sensor systems which utilize diffraction as the transduction method for the detection of physical stimuli or bio chemical analysis. Interaction of these sensors with a specific analyte or stimulus changes the colour, image or brightness of the hologram and these changes can be visualized directly by the user or quantified using simple colour reader technology.

Sensor holograms utilize the principles of volume holography with a Denisyuk holographic grating recorded within a smart polymer system. Unlike conventional holographic recording media, the smart polymers are rationally designed synthetic polymers with receptors that allow them to interact with a highly specific stimulus or analyte. Interaction of the analyte with the hologram causes a change in the swelling state or cross linking density of the polymer, which in turn results a change in the recorded hologram. Preliminary detection of the presence of glucose, alcohol and drugs in the urine can be recognized by using these types of biosensors. These sensors do not replace the requirement of Doctor, but it provides pre stage information to the patients without using costly medical instruments. These sensors are cheaper because one sensor can be used many times also it does not require power to operate.

Experimental details : To prepare good quality thick (of the order of 10 µm) hydrogel film which has the maximum water absorbing capacity and also used for contact lenses, Poly Hydroxyethylmethyl acrylate (p-HEMA) polymer was purchased from Sigma–Aldrich. Initially few grams of polymer grains soaked with distilled water for two hours. Then Ethanol (AR grade) is added to it to prepare the solution of p-HEMA (hydrogel). After that with the help of micro-pipette and specially designed Spin Coating unit (by Apex Instruments limited, Jadhavpur Kolkata) with rpm 7000 (shown in fig.1), polymer thin film is deposited on glass substrates. The uniformity of polymer film and its composition are verified through SEM and EDAX analysis (Fig. 1,Fig.2 and Fig.3).

Fig. 1: Spin Coating Unit

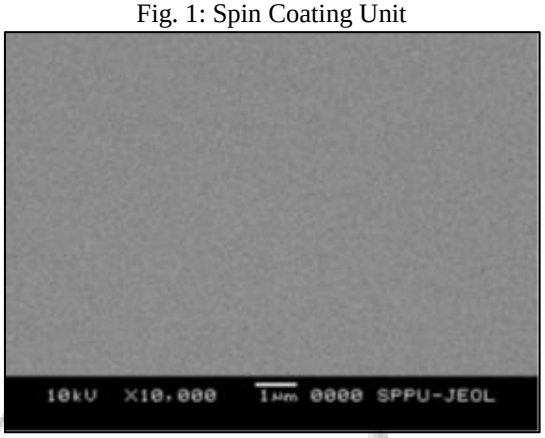


Fig. 2: SEM Image of P-HEMA Film

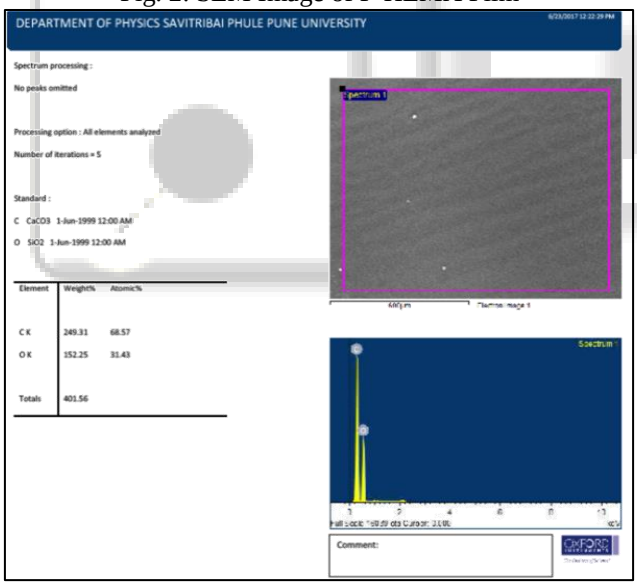


Fig. 3: EDAX Analysis

From the above analysis it is confirmed that the polymer film is ready to be doped with silver nano particles.

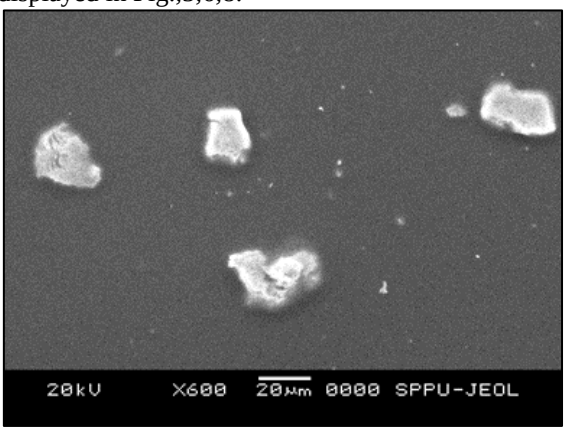
Fig. 3(a): Aloevera Extract for Synthesis of Ag

Fig. 3(b): Silver Nanoparticles

Preparation of silver nanoparticles through Green synthesis method:

Silver nanoparticles are prepared by using red apple extract (Fig.3a, 3b) and aloevera extract. Both the methods are similar. Let me describe the second method. Aloevera leaf is selected for the green synthesis of silver nano particles because it is easily available in the garden. In this method fresh aloevera leafs are collected from the garden. After that it is thoroughly washed with tap water. Then aloevera leaf is chopped into fine pieces with the help of iron free knife. 10 gm of these finely chopped leaves transferred to 250 ml. beaker which contains 100 ml. distilled water and then boil it at 80^0 C for 20 minutes [6]. Allow the solution to cool at the room temperature then aloevera extract is filtered by using wattman filter. Aquous solution of 1 mM Silver nitrate ($AgN0_3$) is prepared and 80 ml.of this solution is transferred to 250 ml beaker. This solution is stirred for 15 minutes at room temperature Then 20 ml. of aloe vera extract is added to silver nitrate solution and continuously stirred it for 30 minutes at room temperature. Allow the mixture to settle for next 24 hours. Then it is observed that gray colour silver nano particles precipitated at the bottom. Silver nano particles are separated by using REMI 12 RC BL centrifuge machine (maximum rpm 12000).

Doped silver nano particles clusters are displayed in Fig. 4a. Also the presence of silver nano particles is verified through UV-Visible spectroscopy (Fig.4b). The size and shape of the silver nano particles synthesis by above mentioned green method are analysed by TEM method which are displayed in Fig.,5,6,8.



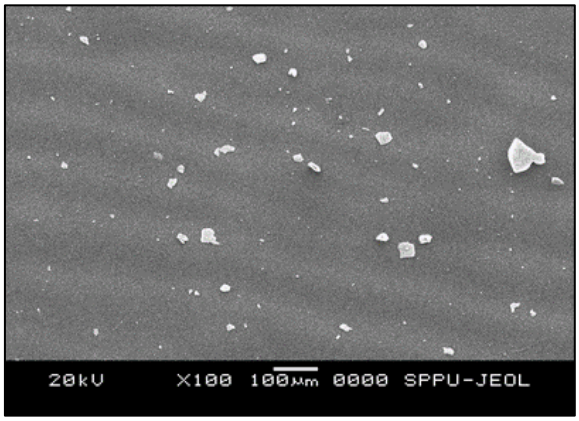


Fig. 4(a): SEM Micrographs Showing Silver Nanoparticles doped p-HEMA Film

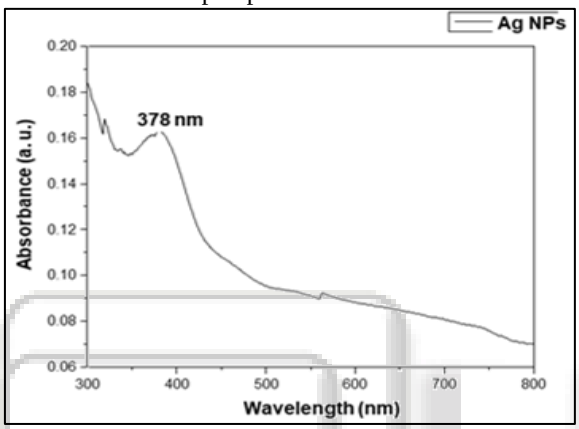


Fig. 4b. UV-Visible Spectrum of Ag Nanoparticles

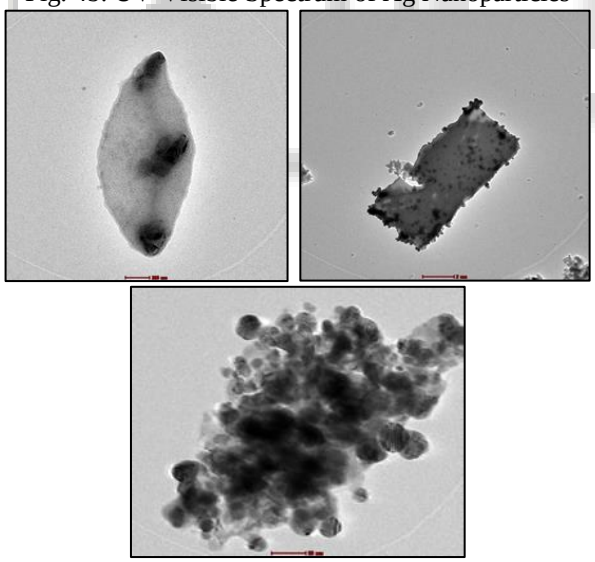


Fig. 5, 6, 7: TEM Micrographs of Silver Nano Particles

The presence of silver nanoparticles is also confirmed through TEM EDAX analysis (Fig. 8). After that silver nano particles are mixed thoroughly into p-HEMA solution with the help of ultrasonic bath at room temperature. This mixture is used to deposit silver doped polymer film on glass substrates by using Spin coating unit. This silver doped polymer film can be used to record the Denisyuk holographic grating by using diode Laser source (20 mw).

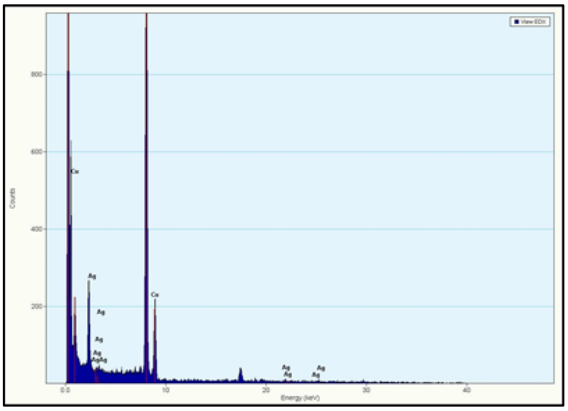


Fig. 8: TEM-EDAX Analysis

At this stage a hologram recording set up is designed by using the components: like i) beam splitter ii) two mirrors iii) beam expander and iv) 20 mw Green diode Laser source which is displayed in Fig. 9. The interference pattern obtained by the above mentioned set –up is shown in Fig. 10. The silver doped polymer film is exposed to this pattern for 24 hours to record the pattern on the film. FESEM photograph of the recorded pattern is displayed in Fig. 11 and Fig. 12.

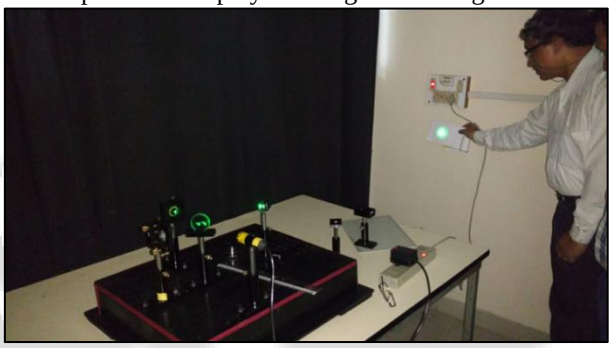


Fig.9 Hologram recording set-up

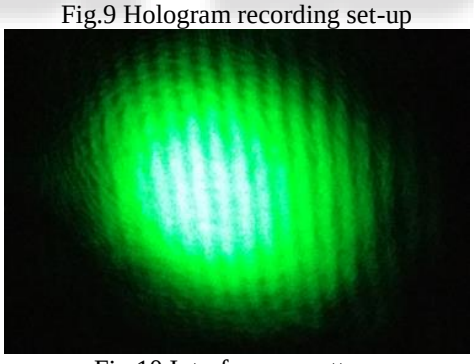
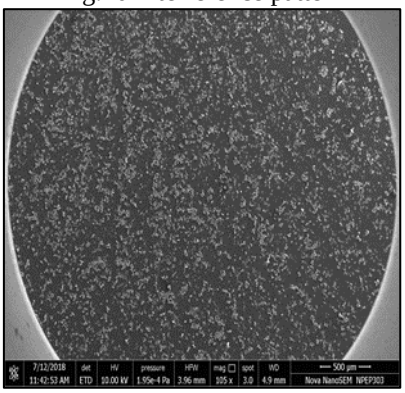


Fig.10 Interference pattern



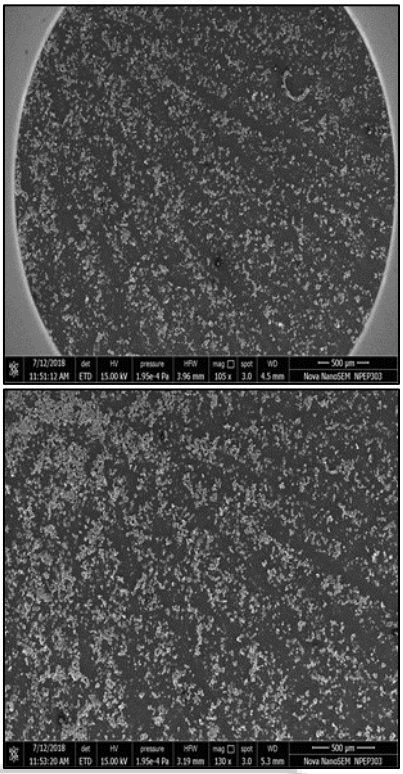


Fig. 11, 12: FESEM Photograph of Hologram Recorded Pattern

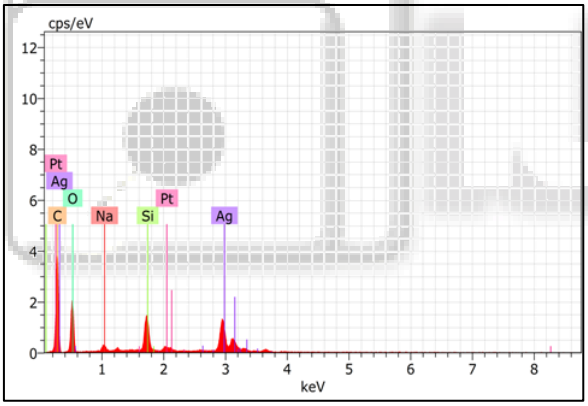


Fig. 13: FESEM EDAX Analysis

The FESEM EDAX analysis also confirms the presence of silver nanoparticles.(Fig. 13).

II. Results & Discussion

In this process we are successful to develop a holographic grating. It contains close lines of silver nano particles which are photosensitive. At this condition if we allow visible light to diffract from this grating, a particular colour spectrum will be visible. In the next step when we will add few drops of urine sample of normal person in this grating. Then due to the absorption of the sample, hydrogel film swells and we know that it has maximum water absorption capacity. Due the swelling nature of hydrogel the distance between the grating lines are changed and therefore nature of spectrum changes according to the Bragg's law of diffraction.

$$2d \sin\theta = n\lambda$$

The change of colour in the spectrum can be observed with the help of suitable receptor and colour reader.

In this way silver doped Hologram film can be calibrated. At this stage urine sample of the patients who is suffering from blood sugar can be added to the holographic film because silver doped hydrogel film has the property of regain its original shape after some time, due to this property it can be used for several times. This process reduces the cost of this method. Due to the presence of foreign elements like glucose molecule in the sample for which silver nano particles are very much sensitive, grating spacing is changed and simultaneously nature of colour spectrum changes. At present optimization of all these work are in progress in our laboratory. Also attempts are taken to improve the sensitivity and quality of Holographic film by increasing the no. of lines in the grating by changing the Laser source and by optimizing particle size of silver nano particles. We obtained preliminary results for optimization of holographic film. After Proper optimization this type of holographic film can be used to design good quality medical sensors.

Acknowledgement

We acknowledge the University research cell of Sabitribai Phule Pune University for sponsoring the project. Also the second phase of this project with adequate fund requirement is submitted to University Research cell to complete the remaining part of the work which are in process.

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