Diagnosis of Skin Health Conditions Using Gold Nanoparticles[#]

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ABSTRACT

This study reports a novel non-invasive method for the detection of skin health conditions using gold nanoparticles (GNP). The feasibility of the use of these GNP in the diagnosis of skin health conditions was non-invasively studied using skin samples collected through tape-stripping method. The skin health conditions were diagnosed based on the visual color change of GNP and the same has been established spectroscopically (UV-Vis) by monitoring the surface plasmon band (SPR) of GNP. This novel non-invasive in-vitro method determines the skin health conditions precisely and can guide the consumer to select the suitable products fit for their skin conditions. It diagnostic can be extended to demonstrate the performance of personal care products. The proposed diagnostic kit can also be used to demonstrate the dermatological conditions to predict the onset of skin diseases. This tool would also be applicable to predict any disturbances in the skin's acid mantle.

Keywords: nanoparticles, diagnosis, health, skin, skin pH, skin moisture, acid mantle

1 INTRODUCTION

The skin is the outermost layer of vertebrates that provides a vital barrier for protecting them from both routine and extreme environmental assaults including exposure to antigens, solvents, ultraviolet light, detergents, microorganisms, toxins, nanoparticles and a variety of physical and chemical insults [1-6]. All these insults alter the skin barrier function and that in turn leads to change in skin-health conditions. Therefore there is an utmost need to diagnose and monitor the skin health conditions regularly for maintaining skin homeostasis. There exist different instruments that can facilitate the skin analysis through measurement of intrinsic factors such as moisture content, transepidermal water loss, skin elasticity, skin color, micro circulation, skin thickness etc. [7-19]. In addition to this there also exist a need of analysing skin conditions with instruments to develop and recommend skin care products for the consumers. **The main limitation of using all these instrumental methods in day to day use by the consumer are** (i) cost, (ii) portability, (iii) complexicity in operation (iv) space etc.

Metal nanoparticles specifically gold nanoparticles have occupied important position in the fields of chemistry, physics, and biology because of their unique optical, electrical, and photothermal properties. Nanoparticles have found potential applications in analytical chemistry and the same have been used as probes in mass spectroscopy, as well as in the colorimetric detection for proteins and DNA molecules [20-21]. Nanoparticles have high potential for fabricating biological labels, biological sensors, bioanalysis and biodiagnosis technologies, diagnosis and monitoring of diseases, drug discovery, environmental detection of biological reagents, and even medical and clinical diagnosis and therapy [22-29].

The present work provides a in-vitro method for both qualitatively and quantatively assessing skin health conditions using the size dependent optical properties of GNP in the presence of skin samples.

2 MATERIALS & METHODS

D(+) Glucose, sodium borohydride ($NaBH_4$) and chloroauric acid ($HAuCl_4$, $3H_2O$) were purchased from Sigma Aldrich (St. Louis, MO, USA). KOH was obtained from SD Fine Chemicals, India Ltd. The adhesive tape of $2x2cm^2$ was used for collecting skin samples. Milipore water was used throughout the experimental works. All spectroscopic measurements were done using a Shimadzu UV-vis spectrophotometer.

2.1 Preparation of Gold Nanoparticles (GNP)

The GNP was synthesise following two synthetic methods, where gold salts such as was chemically reduced usingreducing agents such as D(+) Glucose, sodium borohydride ($NaBH_4$) [30-34].

Method 1. In a 100 mL glass beaker 5 gm D(+) glucose was dissolved in 48 mL water and mixed properly. Then 2 mL of 10^{-2}M $HAuCl_4$ solution was mixed to it. Finally 100 µL of 1M KOH solution was added to it at a time under vigorous stirring. The solution turned wine red indication the formation of gold nanoparticles. The solution was stirred for 10 minutes to ensure the complete formation of

gold nanoparticles in water. Finally the solution was stored overnight at room temperature under dark.

Method 2. 30 mL solution of 2.5×10^{-4}M HAuCl4 in water was prepared in a 100 mL round bottle conical flask and an ice cold solution of $NaBH_4$was addedinto it under constant stirring until its concentration reached to 2.5×10^{-3}M.An appearance of immedite wine red colour indicating the formation of GNP. The synthesized nanoparticles were stored overnight at 4˚C for further use.

2.2 Diagnosis of Skin Health using GNP

Collection of skin samples using tape-stripping method

2×2 cm^2 area were marked on volar forearm and elbow. Apply adhesive tape of dimension 2×2 cm^2 on the marked region and pressed the adhesive tape gently using finger and then remove the adhesive tape containing skin samples.

Treatment of skin samples with GNP

In a 2.0 mL ependorf tube 1.0 mL of nanoparticle dispersion (wine redcolor) were taken. The skin samples collected through tape stripping technique was added to it (skin samples from forearm and elbow). The solution was mixed for 30 seconds using a vortex mixture. The change in color of the GNP solution was followed visually as well as spectrophotometrically by recording the change in the pattern of SPR band of the GNP.

3 RESULTS& DISCUSSION

The UV-Vis spectra for GNP were recorded. The characteristic SPR of the GNP was observed at 520 nm (Figure 1) indicating the presence of spherical GNP of size of 10-20 nm. [35-36]. The color of GNP as well the SPR band remains unafected in the presence of the only adhesive tape without any skin samples..

From Figure 2, one can note that the wine red color of the GNP solution turns blue, when treated with skin samples collected from elbow through tape stripping while the colour changed to violet while traeted with the skin samples collected from volar forearm. The color of GNP gradually changes from wine red to blue, when treated with skin samples collected from panelists having different skin moisture level. The change of color of GNP in the presence of skin samples indicating the change in the aggregation state of GNP under different conditions offered by the skin samples from different regions.[37- 42].

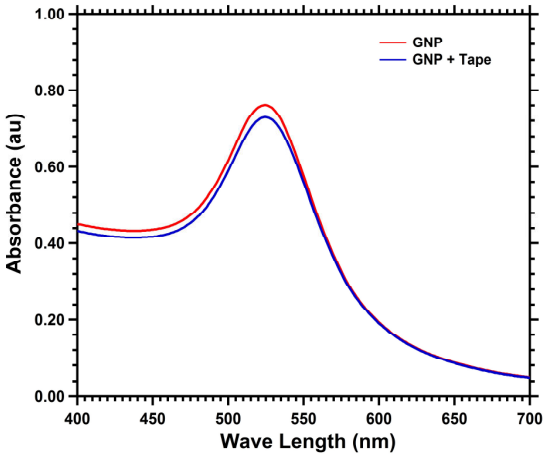

Figure 1. Plasmon resonance absorbance Spectra of GNP in the absence and presence of tape

The surface properties of skin depends on the anatomical location in human body. It is known that skin surface of elbow differ from forearm with respect to moisture content, skin integrity, pH etc and they have different skin barrier function [43]. Skin of volar forearm is more moisturized when compared with elbow skin. In addition to this, pH of the skin surface of elbow reported to be higher than forearm. Therefore the change in color as well as the SPR of GNP in the presence of skin samples (forearm and elbow) could be attributed due to the difference in the biochemical properties (skin moisture level, pH, water soluble protein content, lipid content etc) between the two skin surfaces.

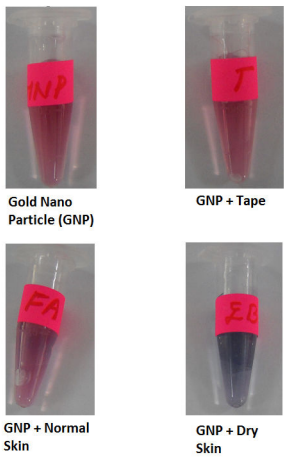

Figure 2. Change in color of the GNP in the presence of skin samples

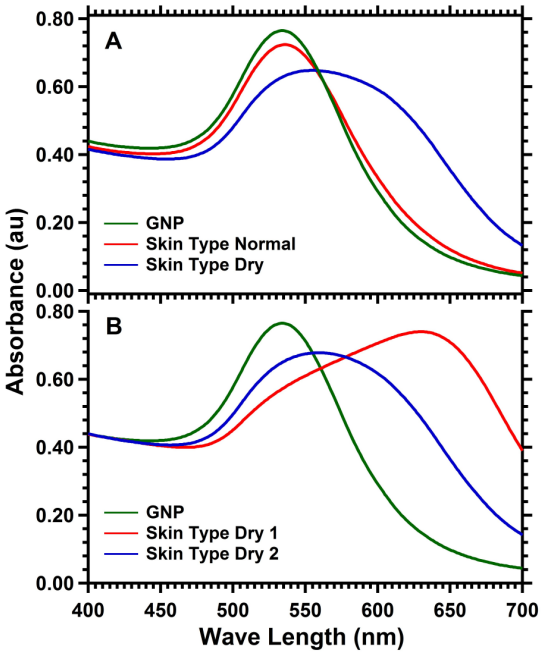

Figure 3. SPR of GNP in the presence of skin samples. Colorimetric responses of GNP towards skin samples of different types (dryness level). The GNP was treated with skin samples for 30-45 sec.

The SPR of GNP was recorded in the presence of different skin samples as described in meterials and methods section. The SPR of GNP undergone a red shift, when treated with dry skin sample. A gradual red shift on the characteristic SPR was observed, when GNP was treated with skin samples of increasing dryness level.

It is reported in the literature that the biochemical properties and barrier function of skin surface differ from normal to dry skin [43]. The major differences between normal and dry skin are moisture level, skin surface pH. The red-shift of the SPR band can be attributed to changes in the shape, size and different state of aggregation of GNP. Therefore, the observed change in spectral profile of GNP in the presence of skin samples might be due to the differences in the biochemical properties of skin samples having different dryness level.The effect of different bulk parameters on the morphological changes of nanoparticles has been described elsewhere [35-42].

Therefore from Figure 3, one can noted that the change in SPR of GNP can be correlated with the skin type having different dryness level.

The effect of pH on the SPR of GNP has been studied and the data has been presented in Figure 4. The change in of SPR of GNP with pH is of great interest. The SPR of GNP was found to be slightly blue shifted with increase in pH. From Figure it can be seen that change in spectral pattern of GNP with buffer solution of different pH is not similar to change in spectral pattern of SPR of GNP treated with skin samples collected from different region of skin. Hence it can be concluded that the change in SPR pattern along with the change in colour of GNP is due to the different skin conditions which is a combination of factors discussed earlier. F The study was conduceted over 30 panelists and similar change in colour and spectral pattern was observed.

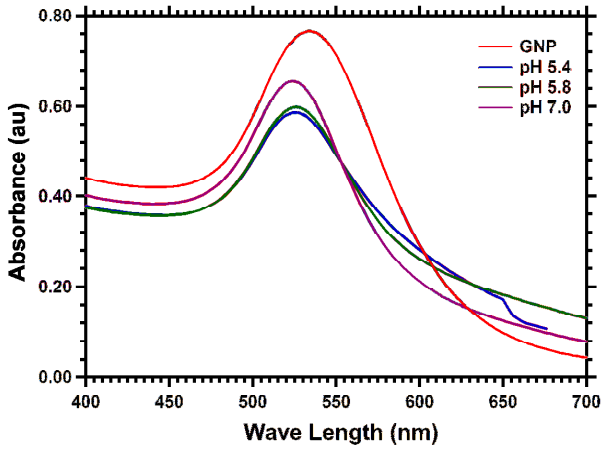

Figure 4. Plasmon resonance absorbance spectra of GNP under varying bulk solution pH

4 CONCLUSIONS

In this work it has been demonstrated that GNP can be used for the detection of skin health conditions both visually and spectroscopically. This non-invasive in-vitro method determines the skin health conditions precisely and can guide the consumer to select the suitable products. This diagnostic method can be extended to demonstrate the performance of personal care products. This diagnostic kit can also be used to demonstrate the dermatological condition to predict the onset of skin diseases. This tool would also be applicable to predict any disturbances in the skin acid mantle. Finally this technique would be useful to evaluate the performnace of different skin care products and recommend the correct product to the consumer depending on their skin conditions.]'

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