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Multiple Twines Defects Detection of Biosynthesized Gold nanoparticles by Using Image Segmentation Tools.

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Abstract:

Nanomaterials are a promising and expanding industry, with gold nanoparticles being highly sought after in various industrial, medical, and environmental contexts. Regrettably, the manipulability of production processes at the nanoscale poses challenges, and nanoproducts frequently manifest localized flaws that compromise their functional characteristics. Hence, the identification of defects holds significance within smart manufacturing systems, as it enables the prompt generation of warnings when faults surpass a predetermined threshold. Additionally, it facilitates the development of production procedures that effectively enhance the physical characteristics of the manufactured materials while effectively managing their defectiveness. In this study, we introduce an innovative approach for identifying the twin defects in gold nanoparticles through the examination of transmission electron microscope images. During the detection phase, we utilized different image processing tools that acquired knowledge of a model that produces sparse representations of the structures that accurately describe the morphology of gold nanoparticles.

Keywords: Orange juice, Image segmentation, gold nanoparticle, Twine's defects.

1. Introduction:

The word "nano" mean something small in nature with diameters in the range of 1 to 100 nm. Gold nanoparticles have been considered valuable area of research for their unique and tunable surface plasmon resonance (SPR) and it has also various applications in the field of biomedical science including drug delivery, photothermal therapy, tissue/tumor imaging, and immunochromatographic identification of different pathogens in the clinical specimens. Cost-effective and eco-friendly procedures for the synthesis of nanoparticles are of interest to chemists, biologists and materials scientists alike, especially highlighted on the efforts to find "greener" methods of inorganic material synthesis [1]. Now a day's gold nanoparticles are widely using for cancer therapy and drug delivery [2]. Lots of scientist used citrus fruits as a replacement of reducing agent for synthesis gold nanoparticles [3-4]. Different fruits juice also used to synthesis low cost silver nanoparticles and it also reported that solar light help the reaction to faster growing naoparticles [5-6]. Famous Australian Kiwifruit have been used for bio- synthesis of gold naoparticles [7]. Now a days due to advancement of image processing classifications and identification easily done with help of various image processing tools. The gray level image which usually contents 256 pixel for that reason scientist have lots of attention from last 15 years.Researches were easily identified their desire spot from common image by using digital image processing techniques. Image processing tools are versatile use in medical field like detection size and shape of brain tumor from C.T or MRI image. Lung cancer already being detected from CT image by using image processing tools [8] Image segmentation is an important process for analysis of image it may be binary or color image and various techniques were used for image segmentation and some of technique also highly recognized. Detection multiple twines defect in nano scale will be challenging task. Thresholding technique have been used to identify the boundary line of defect planes of gold nanoparticles. Thresholding method of image segmentation is a very useful and powerful technics for detect the desired area. The segmented image which was obtained from thresholding can stored easily because output image size has less than input image. The image thresolding process also takes less time to obtain the output. Image threshold value can be calculated through gray level histogram method [9]. Humane ribcage easily segmented from full human body image [10], Histogram equalization used for image contrast enhancement [11]. Defect detection is done from nanofiber by using imge processing algorithm [12].

2. EXPERIMENTAL

2.1 Materials, Characterization and image processing tools

All the reagents were used without further purification. Deionized Milli Q water (DI) with a resistivity of 18.2 MΩ was used throughout the experiment. ($HAuCl4. 3H_2O$) and NaOH were bought from SRL Chemicals Mumbai, India. Orange brought from local market Shillong, India. Orange juice act as a reducing agent as well as capping agent.

Synthesis of gold nano particle was carried out according to the bellow procedures. We havetaken 100 ml of DI water in beaker and water boiled up to 100 ^{o}C with help of magnetic stirrer and hot palate. Just after 5 Moller 5 ml (HAuCl4) acid pour into the beaker and wait for 5 minute then put freshly prepared orange juice into it and stirring for 5 minute. 2 ml NaOH added on the solution for balance the pH upto 3.5. Gold atoms released from the chloroauric acid and aggregated to form nanoparticles (NPs). These steps were repeated continuously until the solution colour changed yellow to win red. Then it was stored in a dark place at 4°C.

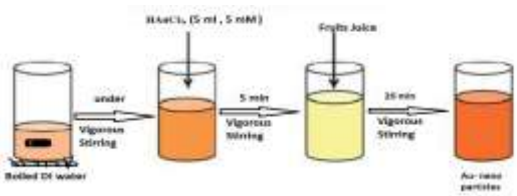


Figure 1: Schematic diagram of gold nanoparticle synthesis with orange juice

2.2 Sample Preparation for Scanning Electron Microscopy (SEM):

Sample preparation for SEM and TEM imaging one of the challenging tasks. First, disperse the AuNP solution with help of an ultrasonic bath forfew a minutes. An ultrasonicator (OSCAR Ultrasonic Pvt. Ltd. Mumbai) was used for this experiment. The instrument operates in the 0-30 kHz range. Then the solution was drop casting into the glass slide for further experiment.

2.3 Image processing steps to find out the twines plane.

Total three steps to determine the defect plane, first image preprocessing for the image enhancement, second is image thresholding for the segmentation of twines plane region from gold nanoparticles and finally post processing for highlight the segmented twines defect regions.

Step 1 (Histogram Analysis): Input TEM image of gold nanoparticles at the resolution scale of 10 nm was acquired (Figure. (a)) and the image dimension was 2688 x 2672 pixels at the bit depth of 8 bits. In order to enhance the contrast of the input image, histogram equalization applied and followed by median filtering at radios of 7 pixels (Fig. (b)).

Step 2 (Image Thresholding): After the preprocessing of the AuNPs image Otsu Thresholding method was deployed to segregate the image of gold nanoparticals from the image background (Fig. (c)). After that back ground have been subtracted for highlighted the four (4) grounds objects (Fig (d)) then the thresholding method was applied to get twins plane impression (Fig. (e)).

Step 3 (Image post processing) After the segmentation, it was found the granules were appeared near to the gold nanoparticles which are removed using median filtering and at the end twins plane segmented very accurately (Fig. (f)).

3. Results and Discussion:

For the present work a (Perkin Elmer, Lambda 750, (USA) spectrophotometer was used. A total of 3 ml Au NPs-solution was introduced into the quartz cell and the absorbance spectra were recorded for the time interval of 1 min. The range selected for the scanning wave length was 400-700 nm. Figure 2 shows that the appearance of the pick in 535 nm observed that the particle size around 10 -50 nm. The UV-Visible absorbance spectrum remain unchanged after one month of the sample.

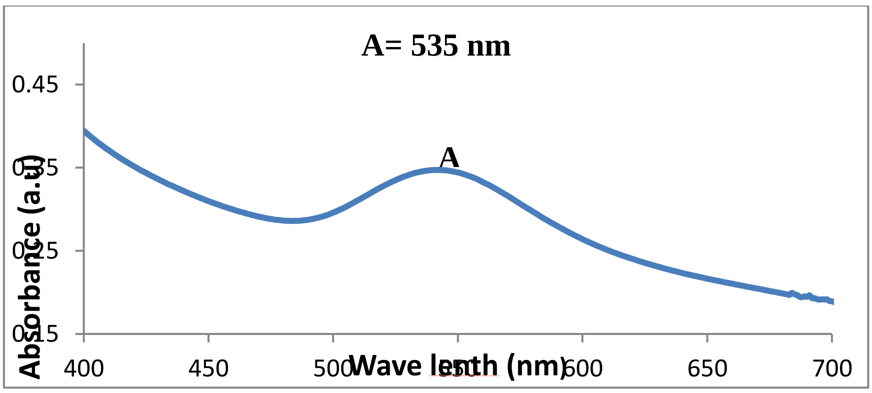


Figure 2: UV- Visible spectra of as synthesized gold nanoparticles.

Scanning electron microscopy (ZEISS, EVO 60, Germany) was performed for the morphological analysis of the gold nanoparticles. In Figure 3 indicates particles are not visible properly when the sample was dried, the evaporation of water and the resultant surface tension caused the particle to come closer and it was formed cluster. Au-NP cluster were appeared in the SEM micrograph.

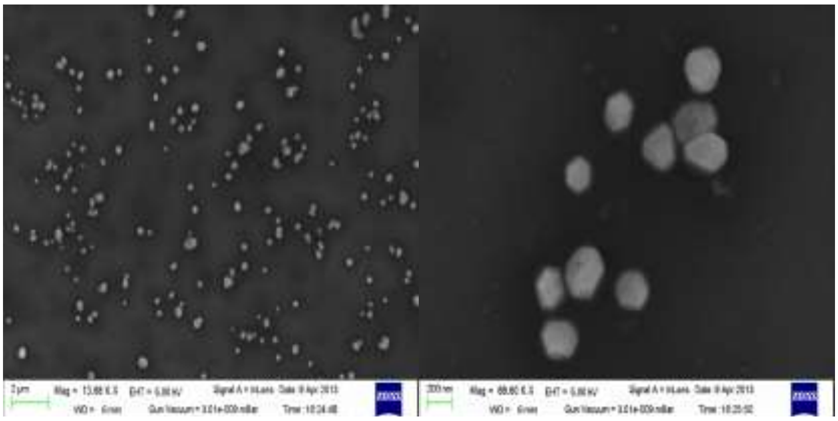


Figure 3: SEM micrograph of Gold Nanoparticles produced by orange juice

3.2 Transmission Electron Microscopy:

Figure 4 shows the TEM micrographs (TECNAI G, FEI, Netherlands) of the as-synthesized gold nanoparticles. TEM photograph shows that Au nanoparticle's shape were uniform and size around (10- 50 nm). Multiple twines defect inside of the gold nanoparticle were identified from TEM image. It's may happed due to less time of atomic arrangements during formation of crystal structure. Selective Area Elcetron Diffraction (SAED) pattern also confirmed that [1 1 1] zone axis with hexagonal symmetry. It also determined that nanoparticles are single crystalline in nature.

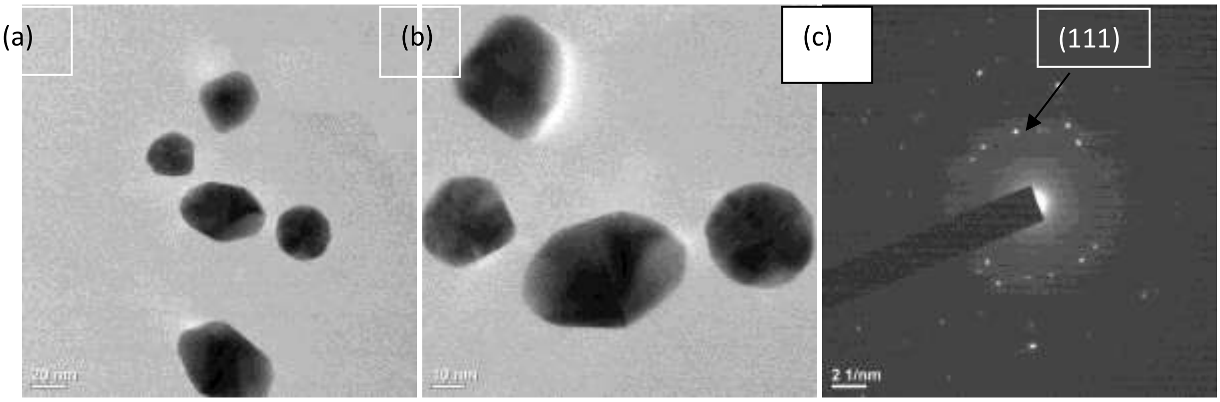
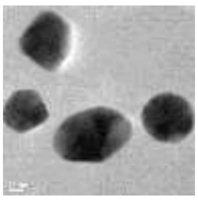
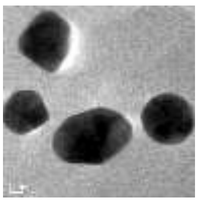


Figure 4: (a), (b) TEM micrograph of Au-NPs and (c) SAED pattern of gold nanoparticles.

Figure 4 shows that (a) original TEM Image of gold nanoparticles, (b) after histogram equalization and also applied median filtering for deduct the back ground noise. Image (c) described the morphological structure of Au-nanoparticle of calculated the Thresholding value. Image (d) was the back ground subtracted image, here only AuNPs particles are visible. In the image (e) twines plane were segmented from defective gold nanoparticles. Image (f) is the final image of twines defect.



(a)



(b)

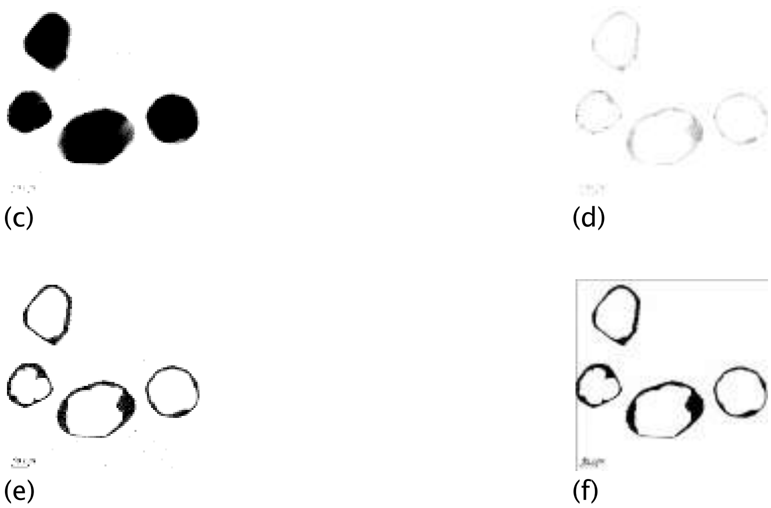


Figure 4:(a) Original TEM image of gold nano particles (b) Histogram equalized image followed by median filtering (c) Thresholding image (d) Background subtracted image (e) Twins plane segmented image (f) Post processed image.

4. Conclusion:

We propose a set of anomaly detection procedures that effectively identify flaws in gold nanoparticles. The efficacy of the proposed tools in detecting minuscule faults and their efficient image processing capabilities have been demonstrated through experiments done on a limited number of transmission electron microscope pictures. Therefore, these technologies can be utilized in intelligent manufacturing systems to manufacture a large quantity of nanoparticles without any detectable impurities, in order to monitor the quality of the resulting material through spot inspections. The implementation of these checks enables the adjustment of production process parameters and, when conducted on a regular basis, triggers alarms when the quality of output fails to meet a desired level. This approach offers both economic and environmental benefits. Current research focuses on developing novel dictionary-learning techniques to leverage instances of detecting defects at the nano scale.

Reference:

1. Wendy J.C.G, Joseph M.S, Rajesh R.N, (2008) Bio - directed synthesis and assembly of nano materials, J. Chem. Soc. Rev., vol. 37, pp. 2403-2412.
2. Weibo C, Ting G, Hao H, Jiantao S, (2008) Application of gold nanoparticles in cancer nanotechnology , Nanotech. Science Application, vol. 1, pp. 17-32.
3. Moumita M, Suresh CB, Rupashree C, Priyanka U, Arghya A, Dijendar NR, Tarun KM, (2019), Synthesis of gold nanoparticles using citrus macroptera fruit extract: Anti bio-film and anti can cer activity, chemistry select, vol. 4, pp 5714-5723.
4. Chun GY, Can H, Bing G, Wei PC, (2017), Green synthesis of gold nanoparticles using using citrus maxima peel and their catalytic/ antibacterial activity, IET nanobiotechnolog, vol 11, pp 523-530.
5. Naheed A, Seema S, Green synthesis of silver nanoparticles using extract of ananas Comosus, (2012), Green and Sustainable Chemistry, vol. 2, pp. 141-147.

6. Vinh TN, Sunlight driven synthesis of silver nanoparticle using pomelo peel extract and antibacterial testing (2020), Journal of Chemistry, vol. 2020, pp 1-9.
7. Antonio Z, Annalaura I, Reberto L, Stefano N (2020), Green synthesis of gold nanoparticles kiwifruit juice, Chemical Engineering Transaction, vol. 81, pp 1393-1398.
8. Anita C, Sonit SS, lung cancer detection of CT image by using image processing, (2012), IEEE International Conference on Computing Sciences, vol.2, pp. 143-146.
9. Otsu N, A threshold selection method from gray-level histograms (1979) IEEE Trans. Syst. Man, Cyber. Vol. 9, pp. 62-66.
10. Mourya G. K, Bhatia, D Handique A, Bordoloi A, Saha, PS, Swargiary S (2017), Automatic segmentation of human ribcage from 3D medical dataset for diagnosis, International Conference on Innovations in Electronics, Signal Processing and Communication (IESC), pp. 112-114.
11. Hum YL, Khin W, Salim, M. (2014). Multiobjectives Bihistogram Equalization for Image Contrast Enhancement. Complexity. 20. 10.1002/cplx.21499.
12. Diego C, Fabio M, Giacomo B, Ettore L (2017) Defect Detection in SEM Images of Nano?brous Materials, IEEE transactions on industrial informatics, vol. 13, no. 2