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Improving Superior Characteristics of Glass using Graphene-Coated

Dhivya Christo Anitha. S, Lakshmi. V, Mary Jenila. R
Department of Physics, St. Xavier's College, Palayamkottai, Tamil Nadu, India

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ABSTRACT

An interesting method for preparing graphene-coated on the soda-lime glass. This work reveals the structural and optical study of Graphene coated soda-lime glass. The graphene-coated soda-lime glass was prepared by a dip-coating process in the presence of graphene which is obtained by the Hummers method. The coatings cycles were varied. The prepared samples' structure, morphology, and optical properties were investigated via XRD, SEM, EDS, FTIR, UV, and contact angle. The XRD spectra indicated the existence of graphene particles. The FTIR spectroscopy technique identifies the functional group present in the sample. The morphology of the graphene-coated soda-lime glass was characterized by SEM analysis. The elements present in the sample were analyzed using EDS spectra. The energy bandgap was identified by Ultraviolet spectroscopy and the bandgap was high for graphene-coated glass. The contact angle value is increased for coated glass compared with soda-lime glass.

Keywords : Graphene, Soda-Lime Glass, Modified Hummers Method, And Contact Angle

I. INTRODUCTION

One of the most popular subjects in the world of nanomaterials and nanotechnology is graphene-based nanostructured materials. [1] Because of its low density and outstanding mechanical properties, graphene is an attractive reinforcing material [2,3]. Graphene is a two-dimensional honeycomb lattice of carbon atoms. one-atom-thick graphene is flexible and transparent, in addition to being 100 times stronger than steel [4]. Graphene has unique features that distinguish it from other types of carbon. While some qualities, like density, are lower in graphene, its thickness is higher when compared to steel. Thermal conductivity is one of graphene's features [5]. High carrier mobility, specific surface area, thermal conductivity, optical transmittance, and flexibility with intrinsic tensile strength and young's modulus are all characteristics of graphene. With a low absorption of 2.3 percent, graphene is remarkably transparent to visible light [6,7]. By employing some graphene as a filler in a high-quality polymer matrix nanocomposite coating, the coating's performance can be greatly improved. ass is a non-crystalline amorphous solid with a wide range of uses, including dinnerware, vehicles, packaging, construction, electronics, optical devices, communication, and renewable energy [11]. The most common form of glass is soda-lime glass, also known as soda-lime-silica glass, which is used for windowpanes and glass containers (bottles and jars) for beverages, food, and various other items. graphene-coated Electrostatic self-assembly [12], coupling agent [13,14],

electrophoretic deposition [15,16], and dip-coating procedures [17-19] have all been used to make glass. The dip-coating approach is the most effective way to generate aligned and layered structures among these technologies. This work presented a dip-coating method for making graphene-coated soda-lime glass and investigated the structural, morphological, and optical properties using XRD, SEM, and UV. For self-cleaning capabilities, contact angle analysis was performed on the samples.

II. METHODS AND MATERIAL

Graphite flakes, Sulphuric acid (H2SO4), sodium nitrate (NaNO3), potassium permanganate (KMnO4), hydrogen peroxide (H2O2), Polyvinyl alcohol (PVA), soda-lime glass was used in the process. The materials were purchased from Sigma Aldrich chemical company. All chemicals were acquired in the purest form.

2.1 Preparation of Graphene Coated Soda Lime Glass
Graphene oxide was synthesized using the modified Hummers method. The GO was reduced to graphene by the thermal reduction method [10]. The graphene was dispersed in acetone, added with PVA, and stirred for 1hour to obtain a coating solution. The soda-lime glass was properly cleaned and handled at 1200 C for evacuated the organic residues. The size of the glass is around 1cm in length and 1mm in thickness. The glass was dip-coated with graphene at a speed of 0.1 m/s. The graphene-coated glass was dried in an oven at 120o C for three hours. The coating cycles were varied for 5,10,15 and 20 cycles. Finally, we collected graphene-coated glass and the results are discussed.

III. RESULTS AND DISCUSSION

3.1 XRD analysis

The XRD pattern was obtained from fig (1a) for pure glass substrate. Due to heat treatments, the spectra were observed as intensive sharp peaks. It shows that the sharp intensive peak at 2θ=5°and 23.760, in the glass pattern is due to the high composition Si present in the glass material. The XRD pattern shows only a broad diffraction peak with no peaks associated with any crystalline phase, as expected for an amorphous structure [20].

The graphene has a strong and sharp diffraction peak at 2θ = 26.52° fig (1b) corresponds to the (003) plane of hexagonal graphite structure with the interlayer spacing of 3.44A°. The XRD pattern obtained for 10 times coated glass is shown in fig (1c). The small peak at 2θ=19.890 suggests the existence of unoxidized graphene. The XRD pattern of coated glass samples shows that no extra peaks rather than carbon are present in the samples. [21]. The graphene has a strong and sharp peak, as shown in figures (1d) and (1e). The peak of 19.8750 vanishes. This indicates that the graphene has been oxidized as a consequence of the large heating temperature.

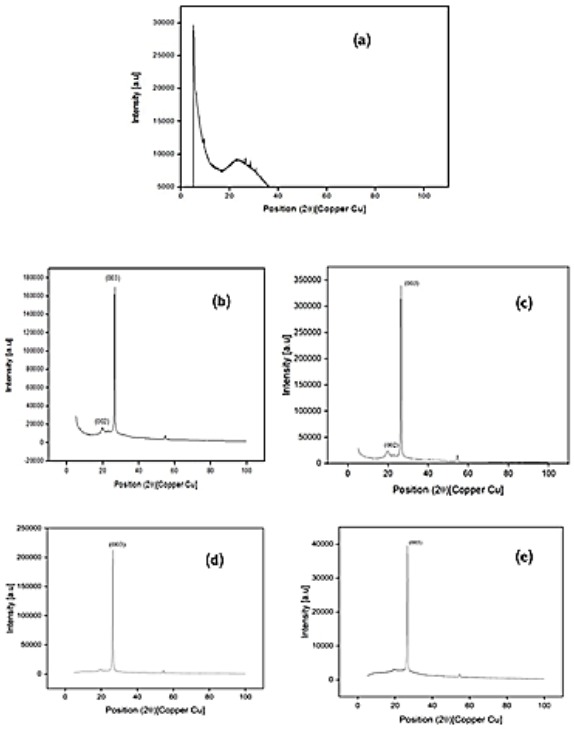

Figure 1. XRD images of (a) pure soda-lime glass (b) 5t graphene-coated glass (c) 10t graphene-coated glass (d) 15t graphene-coated glass (e) 20t graphene-coated glass

3.2 FTIR Analysis

Fig (2a) shows the FTIR spectra of the pure glass substrate. The FT-IR spectral vibrations in the present glass are categorized into well-defined infrared active modes observed around 3534, 2925, and 2852 cm-1 The broad bands are due to various combinations of high degeneracy vibrational states, thermal broadening of the lattice dispersion, and mechanical scattering of samples. The conventional broadband observed at 3534 cm-1 is due to the hydroxyl groups of O–H stretching vibrations. A band observed around 2921cm-1 is an indication of the existence of hydrogen bonding.

The peak of graphene present in the FTIR spectra (fig 2b) shows that C-H stretching vibrations are found at 2910.63 cm-1 were significantly reduced due to deoxygenation. The bending vibrations CH3 at 1367.23 cm -1 were still observed and C-C stretching vibrations at 869.91 cm -1 became sharper, which were caused by remaining carboxyl groups even after thermal reduction.

The FT-IR spectra of 10 times coated glass were presented in fig 2c. The peak shows a broad peak that appeared at 3694.67cm-1in the high-frequency area attributed to the stretching mode of the O-H bond. The band observed at 1391.4 cm-1 was assigned to C-H bending. The peak at 1001.07 cm-1 corresponds to C-O stretching vibration [22] the FT-IR spectra of 15 times coated glass were presented in fig 2d. the peaks show a broad peak that appeared at 2321.14 cm-1 corresponding to stretching vibration of C-H. The FT-IR spectra of 20 times coated glass were shown in Figure 2e, with the peaks corresponding to the C-C triple bond stretching at 2246.67. The presence of PVA in the substance employed as a coating agent for the coating process is responsible for the additional sharp peaks.

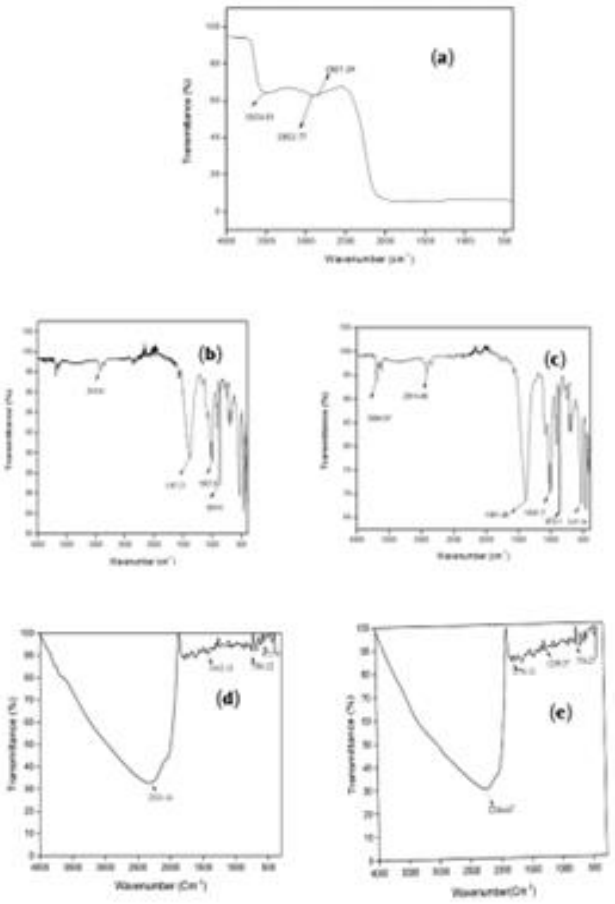

Figure 2. FTIR images of (a) Pure glass (b) 5t graphene-coated glass (c) 10t graphene-coated glass

3.3 UV analysis

a. Absorbance

Fig 3 shows the absorption spectra of pure and graphene-coated glass. The cut-off wavelength of pure glass, 5 times coated and 10 times coated is around 308 nm, 303nm, and 240 nm respectively in the near-ultraviolet region. The absorption spectra of glasses are due to variation in concentration ions and glass composition. The absorption spectra for 5t coated are exhibiting n-π* transitions of C=O bonds. The absorption spectra for 10t coated is the peak transition of the π=π* which indicates the groups on the graphene surface were conjugated structures [23]. The peak transition n-σ* corresponds to C=C bonds in the absorption spectra of 15t and 20t coated glass. The bandgap energy for pure glass is around 4.02 eV, and

for 5t, 10t, 15t, and 20t graphene-coated glass, it is around 4.09 eV, 5.1 eV, 5.23 eV, and 5.27 eV.

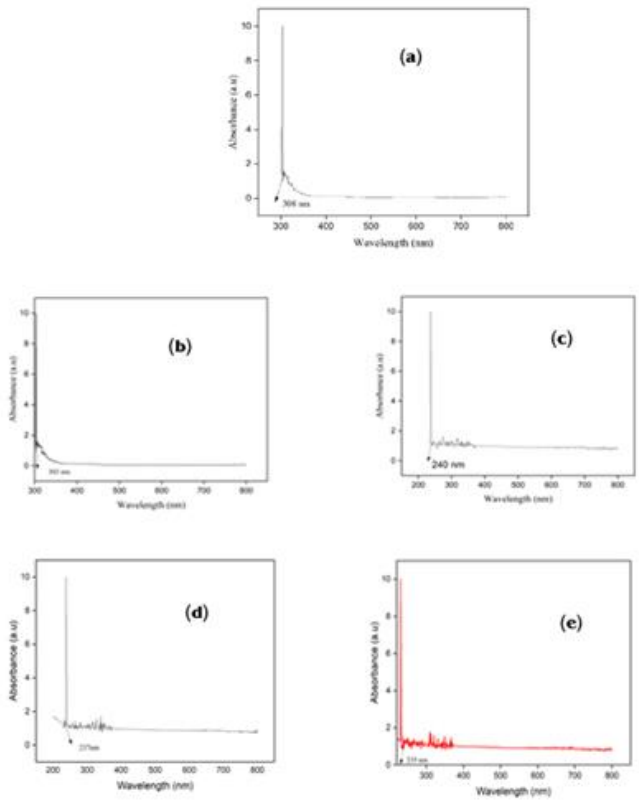

Figure 3 UV absorbance of a) pure glass b) 5t graphene-coated glass c)10t graphene-coated glass d)15t graphene-coated glass e) 20t graphene-coated glass

3.4 SEM and EDAX analysis

Fig (4a-c) shows the typical SEM images of pure and graphene-coated glass. From fig (4a) the surface morphology of glass shows the irregularity of the atoms. The atoms are distributed irregularly shows that the glass is amorphous. The images verify the results of porosity and mechanical strength of samples [24]. Fig (4b) shows that the graphene Nanosheets consist of randomly aggregated and crumpled thin sheets which also observed wrinkles and folds on the surface of the glass. From fig (4c), the graphene Nanosheets are pasted on the glass substrate. This confirms that the graphene Nanosheets are produced from the exfoliation of graphite [25]. The graphene nanosheets are crushed due to heating temperature differences in figures (4d) and (4e).

Figure (5a) shows the EDAX spectrum of the soda-lime glass substrate. The spectrum showed C, Ca, Na, Mg, O, and Si peaks. Figure (5b) and (5c) shows the EDAX spectrum of 5t and 10t graphene-coated glass. The peaks correspond to carbon and oxygen. The carbon was present as an effect of graphene. It can be seen that sodium, silica, magnesium, and calcium were absent. This is confirmed the graphene was completely deposited on the glass substrate. There is also a reduction in the percentage of oxygen and an increase in the percentage of carbon compared with soda-lime glass [26]

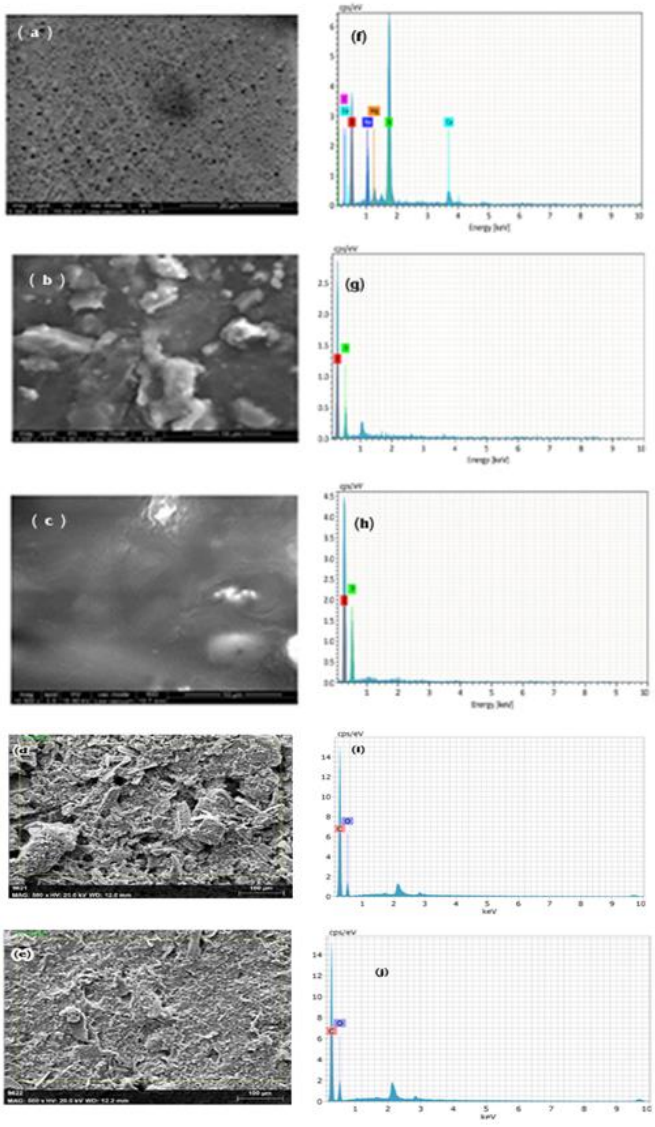

Figure 4 (a-e) SEM images of pure and graphene-coated glass & (f-j) EDAX spectrum of pure and graphene-coated glass

3.5 Contact angle

Figure 5 (a-e) shows the contact angle of soda-lime glass and coated glass. Soda-lime glass is a hydrophilic material. Glass-coated windows are vital for the self-cleaning of high-rise building windows. Water droplets roll over the surface when the glass nature is hydrophobic. As titanium dioxide is a popular choice for self-cleaning surfaces, the contact angle value does not rise as the number of coating cycles increases. [28]. Since graphene is a hydrophobic material, it changed the character of soda-lime glass when it was coated with it. The contact angle gradually raised over coating cycles when graphene was coated on the glass surface as shown in figure 6 The contact angle value is shown in figure 7 if we increase the coating cycles glass will become a hydrophobic material.

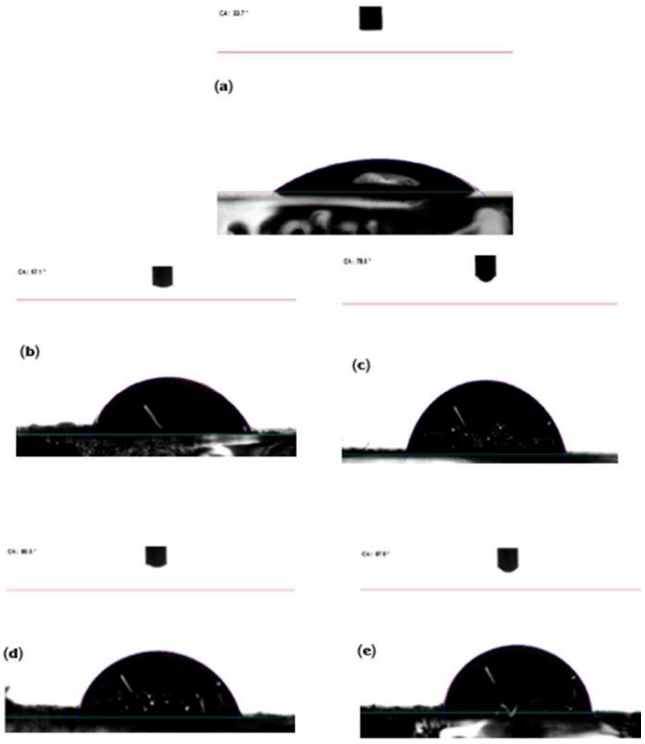

Figure 5 contact angle of a) pure b) 5t graphene-coated glass c) 10t graphene-coated glass d)15t graphene-coated glass e)20t graphene-coated glass

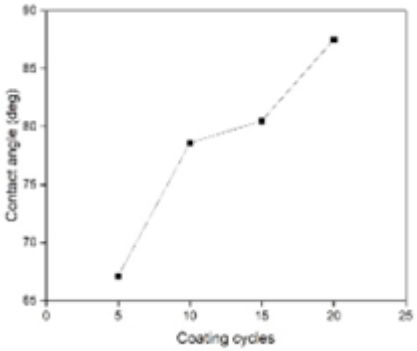

Figure 6 contact angles of thin films with coating cycles.

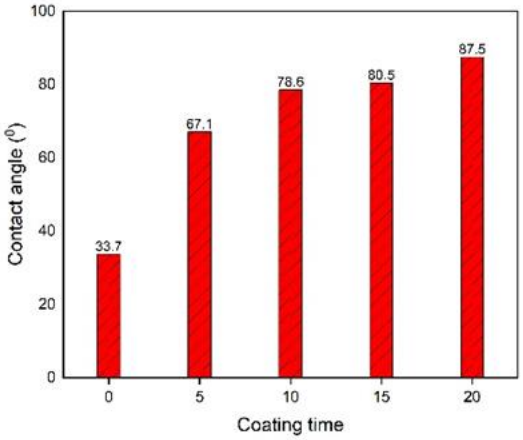

Figure 7 contact angle value for thin films

IV.CONCLUSION

The Hummers modified method was used to make graphene. A dip-coating method was used to coat the graphene on the glass. Five, ten, fifteen, and twenty coating cycles were used. Various characterization techniques were used to evaluate the structural, morphological, and optical features of the produced samples. When compared to pure glass, coated glass has a large bandgap value. As the number of coating cycles rises, the contact angle value for coated glass increases.

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