INTRODUCTION

Thin film nanotechnology is just a wing in nanoworld in which involves fabricating a layered thin coating on the desired substrate at nanoscale level. Mostly, the current research has been focused on by developing metal oxide nanostructures. It has enormous applications; a single thin film grown on the desired substrate can act as a multiplier in photonic applications [1]. The glass plays significant architectural material and used in various opto-electronic applications such as displays, automobiles, anti-reflection coating, windshield, solar photovoltaic panels etc. The individual fabrication of thin films with a layer-by-layer arrangement creates a multilayer structure that can support interference properties in achieving the reflector configuration [2]. These inspired researchers in the field of photonics to create a biomimetic structure known as a photonic crystal, also known as a dielectric single or multilayers. The creation of a biomimic structure inspired by the above mentioned nature living creatures that can reform as a dielectric reflector begins with the formation of individual thin films of the desired materials [3-5].
such as self-cleaning (super hydrophilicity), anti-fogging and anti-reflection coating. Shukla & Subramanian [12] presented the structural colours by growing TiO\textsubscript{2} nanorods on the substrate and polyethylene terephthalate substrates. The obtained experimental results were compared with the theoretical calculations. This color based thin film transformed at superhydrophilicity state by a self-purifying process.

Kumar et al. [13] synthesized 2D-TiO\textsubscript{2} heterostructure and capped MoS\textsubscript{2}@TiO\textsubscript{2} nanomaterials by using the hydrothermal method. They demonstrated that MoS\textsubscript{2}@TiO\textsubscript{2} heterostructure layer was shown dye-sensitized solar cell performance and significantly improved conversion cell efficiency of 3.3%. The SiO\textsubscript{2} and TiO\textsubscript{2} thin films are useful for various applications for example thin film solar cell backside reflector also known as distributed Bragg reflector (DBR), anti-reflection coating (ARC) and photovoltaic materials in dye sensitized solar cell devices (DSSCs), photocatalytic, light emitting device (LED) etc. [14,21].

In this work, the synthesis and characterization of TiO\textsubscript{2}/SiO\textsubscript{2} thin film coating on the glass (substrate) via the sol-gel spin-coating process is carried out.

**EXPERIMENTAL**

All reagents and solvents were of analytical reagent grade and used without further purifications. Titanium isopropoxide (TTIP, C\textsubscript{12}H\textsubscript{28}O\textsubscript{4}Ti), tetraethyl orthosilicate (TEOS, SiC\textsubscript{8}H\textsubscript{20}O\textsubscript{4}), distilled water, ethanol, acetic acid and HCl were procured.

**Preparation of SiO\textsubscript{2} solution:** SiO\textsubscript{2} solution was prepared by sol-gel method by adding dropwise TEOS to a solution of acetic acid (1.7 mL) and ethanol (10 mL) with constant stirring for 5 min using a magnetic stirrer. Here, tetraethyl orthosilicate was taken as a source for silicon and acetic acid was used as a chelating agent. By allowing the above solution to vigorous stirring for 2 h, the solution was taken out from magnetic stirrer and kept for aging at room temperature for 24 h.

**Preparation of TiO\textsubscript{2} solution:** TiO\textsubscript{2} precursor solution was prepared by using titanium tetraisopropoxide (1.2 mL, Sigma-Aldrich), acetic acid (1.7 mL), ethanol (10 mL) and HCl (few drops). Ethanol and acetic acid were taken into a beaker and stirred for 10 min under constant stirring (500 rpm/min) by using magnetic stirrer (KEMI). Then, dropwise titanium isopropoxide (as source of Ti) was added into the above solution (for 20 min) under constant stirring. The transparent gel was formed with little viscosity and without precipitation; the solution beaker was taken out from the magnetic stirrer (roughly from 15 to 20 min). The prepared solution was kept for 1 h aging at room temperature to get the further viscosity to the solution and used for producing thin films.

**Spin coating technique for thin film coatings:** Spin coating is a technique and used to prepare a smooth film layer by spreading a prepared suspension with the specific range of substrates by under a constant speed (rpm) and pressure. This glass substrate was fixed at particular pressure, which helped to control. The solution or suspension was dropping by dropwise on the substrate. It was rotated under different conditions (parameters) by depositing with the uniform (or smooth) thin film surface. These spin-coated substrates could be shown in a homogeneous (or hetero) rough surface coating. Both TiO\textsubscript{2} and SiO\textsubscript{2} thin films were coated on the glass substrate area (2.5 cm × 2.5 cm) by using spin coater equipment. Initially, the glass substrates were cleaned by ultrasonication process using ethanol, distilled water and acetone. The spin coating settings used to deposit the TiO\textsubscript{2} and SiO\textsubscript{2} thin films were 3000 rpm for 30 s. Individually, the single-SiO\textsubscript{2} and single-TiO\textsubscript{2} layer coating on glass substrates were deposited. Simultaneously, both low refractive material and high refractive material were deposited on separate ultrasonically cleaned glass substrates. The sintering temperature applied to SiO\textsubscript{2} was 300 °C and for TiO\textsubscript{2} it requires 500 °C to get an anatase crystal structure as it reported [14,22]. In order to maintain a uniform deposition of the film, each layer deposition film was kept for sintering (targeted temperature depends upon type of material) up to their targeted temperature for 30 min in a muffle furnace.

**Characterization:** The single SiO\textsubscript{2} and TiO\textsubscript{2} layer on glass substrates were characterized by various techniques such as UV-visible (UV-Vis), fluorescence (FL), Fourier transform infrared (FTIR) and scanning electron microscopy (SEM). Thin film nanostructures were examined for their absorbance by using UV-vis spectroscopy (Perkin-Elmer, Lambda 35, USA). The fluorescence light emission spectrum investigation carried out with Perkin-Elmer-LS 45, USA. The functional groups of the prepared samples were analyzed by FTIR (Perkin-Elmer, Spectrum Two, USA) in the range of 4000-400 cm\textsuperscript{-1}. The SEM technique (Carl Zeiss-EVO 18, Germany) displays the surface morphological images of the material at micro or nano structure, revealing its nature.

**RESULTS AND DISCUSSION**

UV-Visible spectral studies: The prepared thin film samples (SiO\textsubscript{2} and TiO\textsubscript{2}) absorbance was calculated at room temperature from the wavelength of 300 to 1100 nm. Initially, Fig. 1 gives the absorbance spectra of single layer of SiO\textsubscript{2} and TiO\textsubscript{2} thin films, which are prepared using sol-gel and spin coating techniques. These thin films have decreasing the absorption in the ultraviolet region (at 340 nm-SiO\textsubscript{2} and 356 nm-TiO\textsubscript{2}). Slightly, the TiO\textsubscript{2} deposition depicted increased absorbance as compared to SiO\textsubscript{2} thin film. These findings show that the created thin film can function when exposed to both UV and visible light, which is agreement with the reported literature [23-26].

Fluorescence spectral studies: The excitation wavelength at 380 nm, the fluorescence spectra of both thin films showed the highest emission spectrum in between 733-798 nm indicates the substrate, which was used during the testing the samples (Fig. 2). However, the prepared single layer of SiO\textsubscript{2} and TiO\textsubscript{2} thin film showed emission peak at 476 and 475 nm [27,28].

FTIR spectral studies: The Fourier transmission infrared (FTIR) spectra of single layer SiO\textsubscript{2} and TiO\textsubscript{2} coating on glass substrate is depicted in Fig. 3. The prepared sample chemical compositions confirmed the presence of anatase phase (O-Ti-O) at 940 cm\textsuperscript{-1} and asymmetric stretching Si-O-Si vibration modes at 1186 cm\textsuperscript{-1} [27,29]. Also, the peaks at 1379 and 1630 cm\textsuperscript{-1} in the TiO\textsubscript{2} deposition revealed its nature.

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Morphology: Fig. 4a-b shows the morphology of thin films deposited on glass substrates at high magnification of 200 nm and 2 µm. The smooth surface morphological images depict a single layer of SiO₂ and TiO₂ thin film. A single layer of SiO₂ and TiO₂ thin film composes the surface morphological images appear to be smooth, however, some of the amorphous nature particles appeared on the sample surfaces were due to the calcinations process [32-38].

Conclusion
This study describes the sol-gel and spin-coated processes used to produce clear thin films of single-TiO₂ and SiO₂ on glass substrates that have been cleansed using ultrasonically. Thin films were characterized by their optical, functional and morphological properties using UV-vis, fluorescence, FTIR and SEM techniques. The UV-visible absorbance spectra showed the strong absorption in the lower spectral region and TiO₂
depicted an enhanced absorbance as compared to SiO$_2$ thin film. The fluorescence spectra of both thin films showed the surface defects and observed the highest emission spectrum in between 733-798 nm. The smooth surface morphological structure was confirmed by SEM analysis. These results demonstrated the successful preparation of the thin films, enhancing their quality and making them suitable for transparent device applications.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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