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Synthesis of AgNPs Using Flowers Exhibiting Different Photoresponse

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Abstract. Biological synthesis or green synthesis of nanoparticles has proven to be cost effective, rapid and safe. Flowers exhibit different colours due to wavelength selective absorption and light scattering. In this study, four differently coloured flowers, i.e. *Bauhinia purpurea* – Fabaceae, *Couroupita guianensis* – Lecithydaceae, *Gerbera jamesonii* – Asteraceae and *Gomphrena globosa* – Amaranthaceae were studied for their potency to synthesize silver nanoparticles. The UV-Vis spectrophotometric analysis of the aqueous extracts of *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa* flowers recorded their respective peaks at 562, 498, 524 and 548 nm in response to their pigments. The synthesized silver particles were characterized through UV-Vis spectrophotometry, scanning electron microscopy, energy dispersive X-ray spectroscopy, particle size analyzer and fourier transform infrared spectroscopy. The resonance peak in the UV-Vis spectrum was recorded at 430, 420, 445 and 435 nm respectively, for the AgNPs synthesized using *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa*. SEM analysis revealed the size range of 107-498 nm for *B. purpurea*, 15-75 nm for *C. guianensis*, 17-51 nm for *G. jamesonii* and 20-91 nm for *G. globosa*. The presence of silver was confirmed by EDS. The silver particles synthesized using the extracts of *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa* showed the average size as 431.3, 71.51, 30.11 and 33.93 nm as assessed through PSA. FTIR studies confirmed the involvement of O-H, N-H, C-C=C, N=O, -NO_2 and C-O stretches. In the present study, the silver particles synthesized by *C. guianensis*, *G. jamesonii* and *G. globosa* were in the nanoscale, whereas those synthesized by *B. purpurea* were in microscale. The synthesis of AgNPs is attributed to the pigments or the metabolites present in the floral extracts. Further studies on the potential of flowers exhibiting different photoresponse in the synthesis of nanoparticles are recommended.

1. INTRODUCTION

The emergence of nanotechnology in several fields, such as catalysis, electronics, drug delivery, tissue engineering and as sensors is primarily due to the distinctive properties of the metallic nanoparticles (NPs), such as their high surface to volume ratio, surface plasmon resonance and other quantum effects [1]. The synthesis of NPs is performed by physical, chemical and biological methods. Biological synthesis or green synthesis of NPs has proven to be cost effective, rapid and safe [2]. Biological sources like bacteria [3], actinomycetes [4], fungi [5], algae [6] and plants [7] are highly exploited for the synthesis of NPs.

Rapid synthesis of NPs by plants is mainly attributed to the phytoconstituents, as reducing, capping and stabilizing agents [8]. Hence, studies on the usage of different plant parts are conducted to synthesize NPs [9]. Among the plant parts, the corolla of flower is found to exhibit different colours as photoresponse to light. The selective absorption of wavelength and light scattering by the floral components contributes to the floral colour [10]. The present study focuses on synthesis of silver nanoparticles (AgNPs) with four flowers exhibiting different colours as their

photoresponse. The following flowers i.e. *Bauhinia purpurea* (Fabaceae), *Couroupita guianensis* (Lecithydaceae), *Gerbera jamesonii* (Asteraceae) and *Gomphrena globosa* (Amaranthaceae) are used in this study. Although many flowers such as *Nyctanthes arbortristis* [11], *Calotropis procera* [12], *Lonicera japonica* [13], *Rhododendron dauricum* [14], *Nelumbo nucifera* [15], *Saraca indica* [16], *Ipomoea indica* [17], *Achillea biebersteinii* [18], *Chrysanthemum indicum* [19], *Tagetes erecta* [20], *Plumeria alba* [21] and *Stenolobium stans* [22] have already been reported for the synthesis of NPs, the present study gives prime importance on the floral color in synthesis of AgNPs.

2. MATERIALS AND METHODS

2.1. Preparation of plant extract

The flowers of *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa* (Fig. 1a-d) were collected from the flower market in Koyambedu, Chennai, India. Aqueous extracts of the flowers were prepared by boiling the corolla with distilled water at a ratio of 1:10 (w/v). The boiled solution was filtered and the filtrate was used for one step synthesis of AgNPs.

2.2. Synthesis of silver particles

Fifty ml of the aqueous extracts of the corolla was added to 500 ml of 1 mM silver nitrate ($AgNO_3$) solution. The solution was incubated in dark for 1 h and centrifuged at 3000 rpm for 10 min, to eliminate the unreacted compounds. The centrifuged supernatant was further washed with methanol and dried.

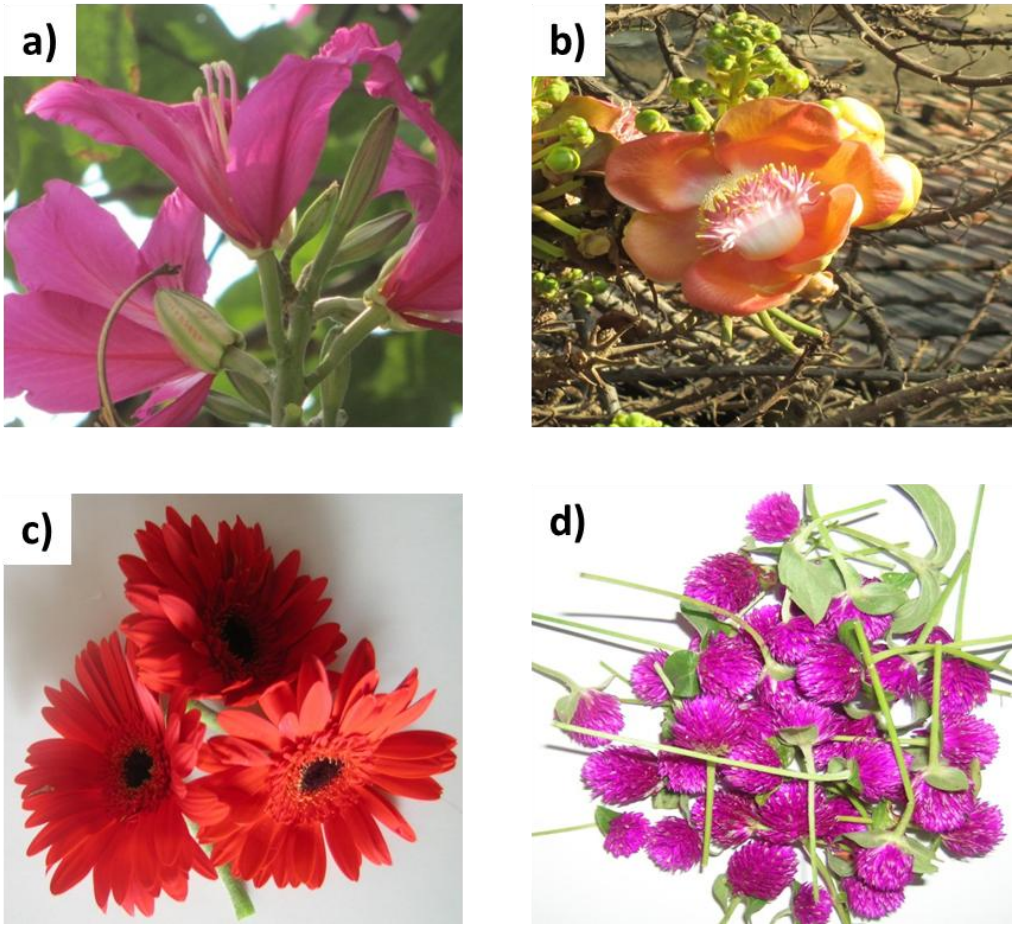

Fig. 1. Flowers of a) *B. purpurea* b) *C. guianensis* c) *G. jamesonii* and d) *G. globosa*

2.3. Characterization of silver particles

The synthesis of silver particles was ascertained by the surface plasmon resonance using UV-Vis spectrophotometer (Cyberlab, USA). The shape and size of the silver particles were observed through high resolution scanning electron microscopy (Quanta 200 FEG). The presence of silver in the particles synthesized was confirmed by EDS (Bruker Corp, USA). The average size of the particles was determined by particle size analyzer (Malvern Zetasizer Nano series). The functional groups involved in the synthesis of silver particles were identified using FTIR analysis (ALPHA-T, Bruker Corp, USA) in the wavenumber range of 4000 to 400 cm^{-1}.

3. Results

UV-Visible spectrophotometric analysis suggested that the floral extracts of *B. purpurea, C. guianensis, G. jamesonii* and *G. globosa* recorded their peaks at 562, 498, 524 and 548 nm respectively, in response to their floral pigments. Reduction of Ag^{+} ions to nanoscale is primarily visualized by the color change to reddish brown (Fig. 2a-d), which is due to the excitation of the surface plasmon. The resonance peak in the UV-Vis spectrum was recorded at 430, 420, 445 and 435 nm respectively, for the AgNPs synthesized using *B. purpurea, C. guianensis, G. jamesonii* and *G. globosa* (Fig. 3).

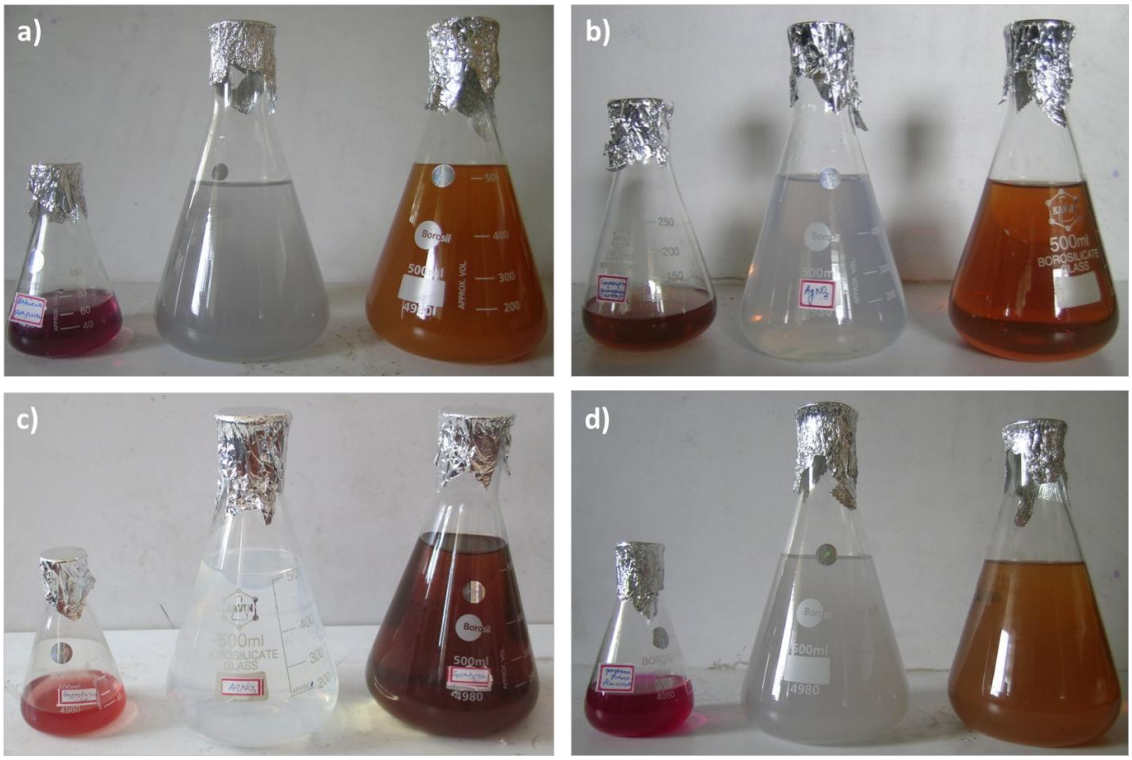

Fig 2. AgNPs synthesized using a) *B. purpurea* b) *C. guianensis* c) *G. jamesonii* and d) *G. globosa*

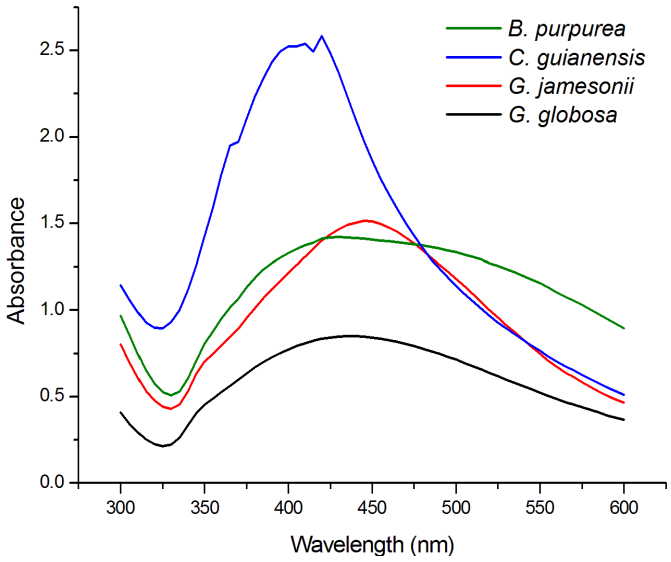

Fig 3. UV-Vis spectra of AgNPs synthesized using floral extracts of *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa*

SEM analysis (Fig. 4a-d) revealed the silver particles to be of spherical to irregular shape with the size range of 107-498 nm for *B. purpurea*, 15-75 nm for *C. guianensis*, 17-51 nm for *G. jamesonii* and 20-91 nm for *G. globosa*. Analysis by EDS confirmed the presence of silver (Fig. 5a-d). Analysis of AgNPs through particle size analyzer revealed the average size of 431.3, 71.51, 30.11 and 33.93 nm for *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa* respectively (Fig. 6a-d).

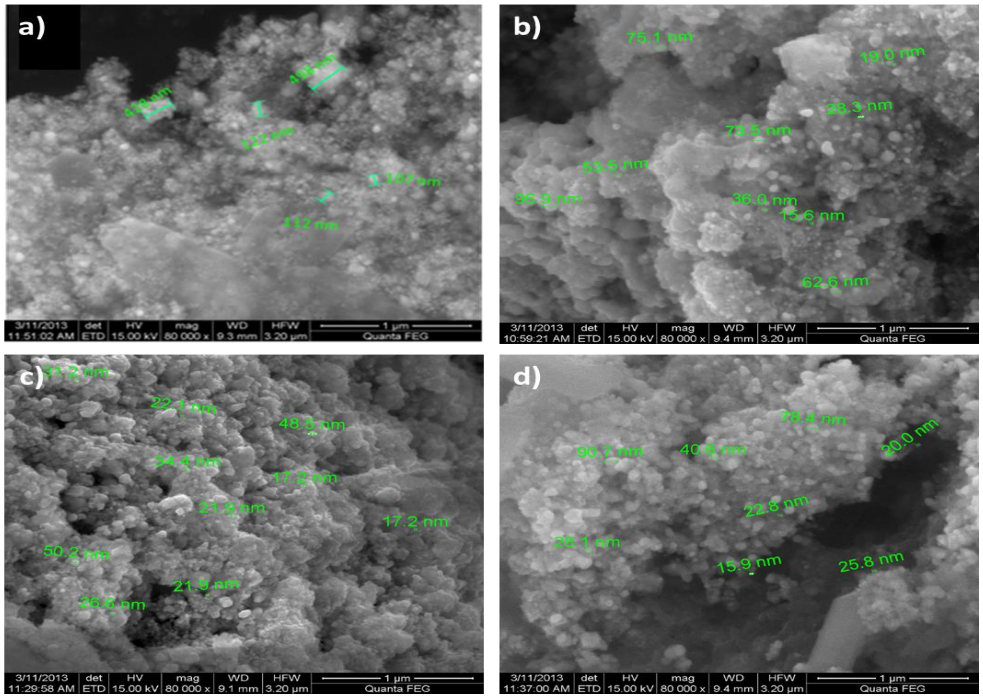

Fig 4. SEM images of AgNPs synthesized by a) *B. purpurea*, b) *C. guianensis*, c) *G. jamesonii* and d) *G. globosa*

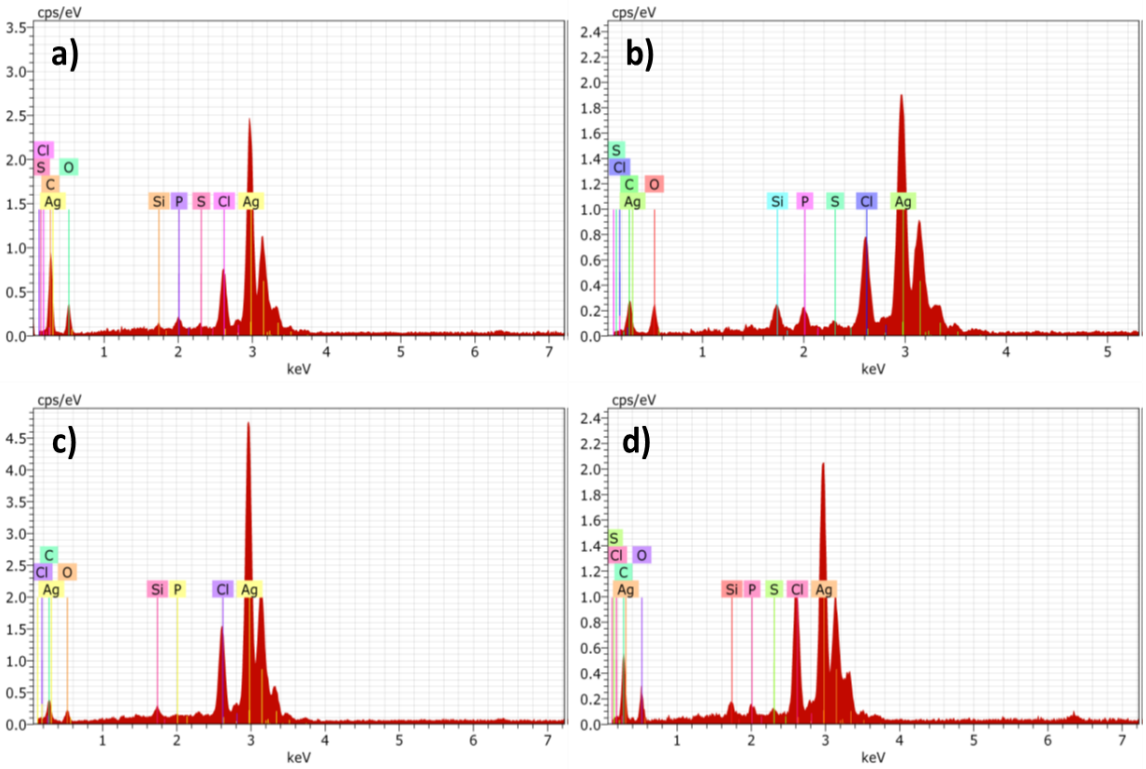

Fig 5. EDS analysis of AgNPs synthesized by a) *B. purpurea*, b) *C. guianensis*, c) *G. jamesonii* and d) *G. globosa*

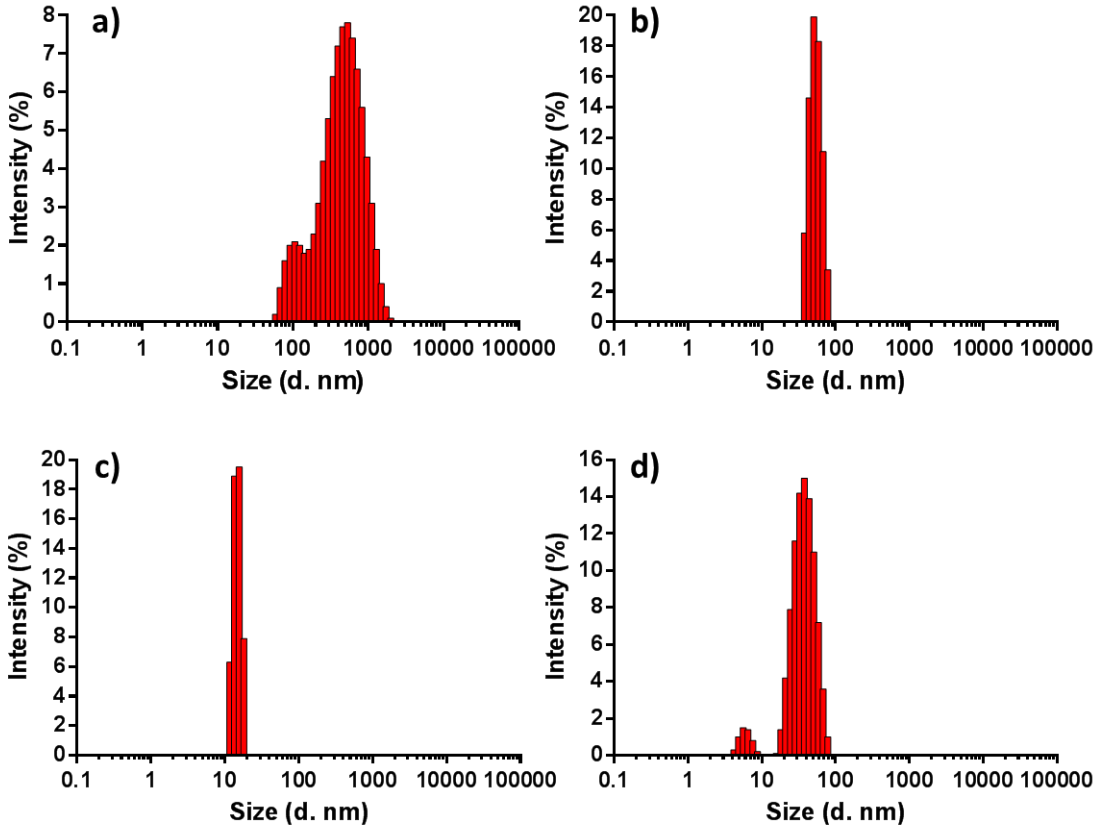

Fig 6. Particle size analysis of AgNPs synthesized by a) *B. purpurea* b) *C. guianensis* c) *G. jamesonii* and d) *G. globosa*

FTIR analysis (Fig. 7) recorded peaks at different wavenumbers for the AgNPs synthesized. The absorption bands at 3817-3513, 3482-3389, 1400 and 1367 cm^{-1} recorded for the AgNPs synthesized from *B. purpurea* corresponded to O-H of phenol/alcohol; N-H of secondary amine; O-H of carboxylic acids; N=O of nitro group and NO_2 of aliphatic group respectively. Similar peaks were recorded in the AgNPs from *G. globosa*. The peaks at 3975-3188, 2381, 1400 and 1367 cm^{-1} revealed the presence of O-H stretch of alcohol or phenol and carboxylic group and N-H stretch of amide groups in AgNPs synthesized from *C. guianensis*. In AgNPs synthesized from *G. jamesonii*, peaks were recorded at 3692-3409, 2687, 1400 and 1367 cm^{-1}, which are associated with O-H of phenol/alcohol; N-H of secondary amine; O-H of carboxylic acids; N=O of nitro group and NO_2 of aliphatic groups.

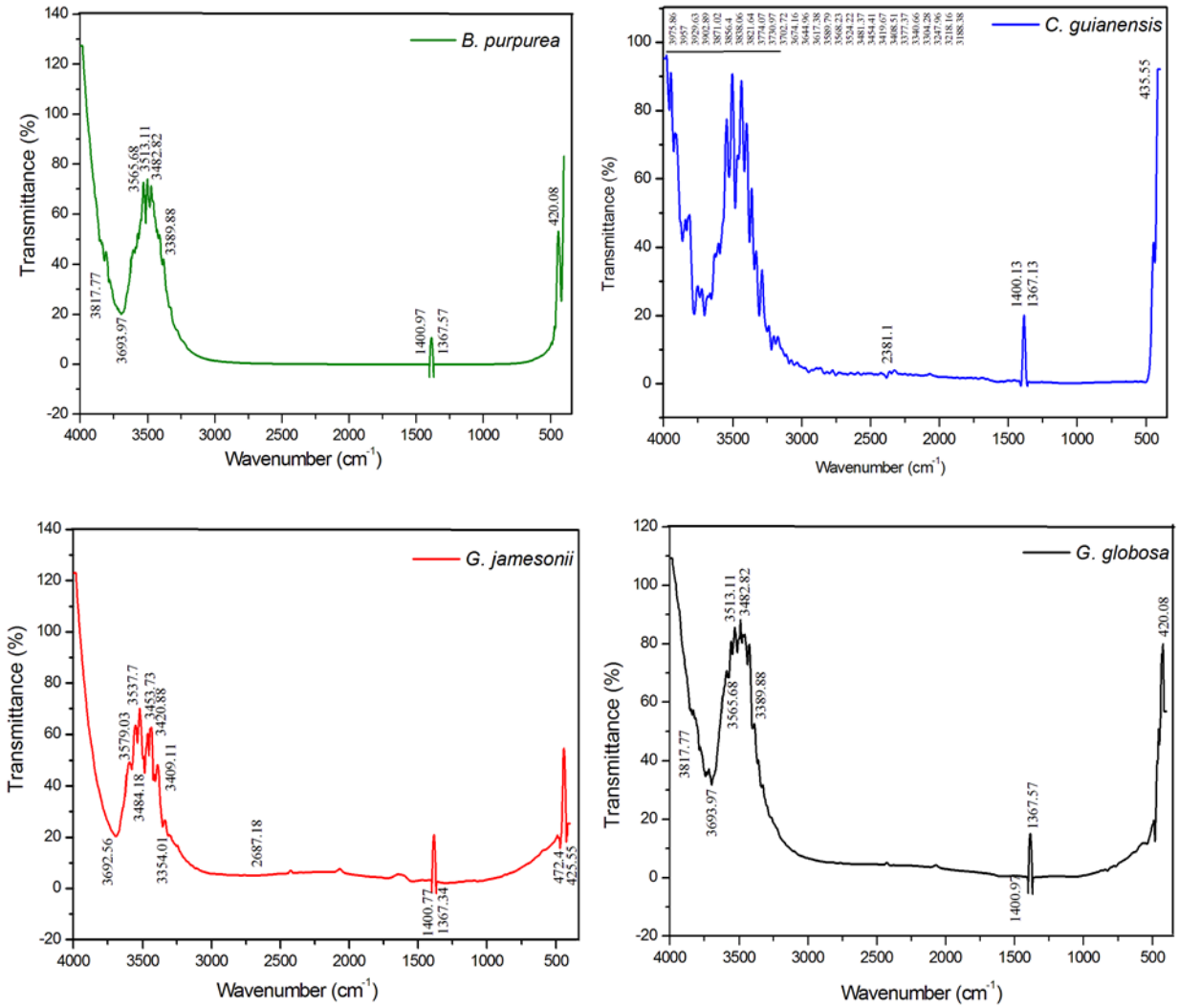

Fig. 7. FTIR spectra of AgNPs synthesized by the flowers of *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa*

4. Discussion

The study demonstrated the synthesis of silver particles by the aqueous extracts of *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa* flowers, exhibiting different photoresponse. The surface plasmon resonance recorded for the AgNPs synthesized using *B. purpurea*, *C. guianensis*, *G. jamesonii* and *G. globosa* was 430, 420, 445 and 435 nm respectively. According to Stamplecoskie and Scaiano [23], AgNPs record surface plasmon resonance at 420-450 nm. It is interesting to note that the size of AgNPs synthesized using different flowers belonging to different families differed drastically. Nanoparticles are defined as the particles exhibiting their size below 100 nm on any dimension [24]. In this study, the size of silver particles synthesized by *C. guianensis*, *G. jamesonii* and *G. globosa* were less than 100 nm, and hence in the nanoscale. However, the particles synthesized by *B. purpurea* showed their size in the range of 107-498 nm, i.e., in microscale.

The variation in colors of flowers is majorly due to their pigments present. It is known that the shades of yellow and orange color in flowers are due to the presence of carotenoids, anthoxanthins or anthochlors, or combinations of them. Red, violet and blue are due to the presence of

anthocyanins and their modifications [25]. Plant based pigments are well known reducing agents and they play an important role in the synthesis of NPs [26].

Synthesis of AgNPs by the extracts of plant parts is due to their phytoconstituents. Tannins, flavonoids and terpenoids were recorded in *B. purpurea* flowers. In addition to the above compounds, saponins were recorded in the flowers of *C. guianensis* and *G. jamesonii*. However, in *G. globosa*, only saponins were recorded [27]. Plant polyphenols have the ability to donate electrons, which reflects their reducing power of metals [28]. The present study clearly shows that *B. purpurea* possesses less reducing nature and hence, less reduction in size of AgNPs when compared to other extracts.

In the present study, FTIR analysis revealed the presence of alcohol/phenol, carboxylic and amide groups in *C. guianensis* and phenol or alcohol group, secondary amine, nitro and aliphatic group in *B. purpurea.* This ascertains the involvement of phenolics, amine and amides as the reducing agent of Ag^{+} ions to Ag^{0} [29]. Thus, the synthesis of AgNPs is attributed to the pigments or the metabolites present in the floral extracts.

5. Conclusion

The present study reports the green synthesis of AgNPs using flowers exhibiting different photoresponse, viz., *B. purpurea, C. guianensis, G. jamesonii* and *G. globosa*. The silver particles synthesized by *C. guianensis, G. jamesonii* and *G. globosa* were in the nanoscale, whereas those synthesized by *B. purpurea* were in microscale. The differences in the particle size might be due to the functional groups of the pigments or metabolites present in the floral extracts. Further studies on the potential of flowers exhibiting different photoresponse in the synthesis of nanoparticles are recommended.

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