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CYANOBACTERIAL PHYCOBILIPROTEINS: A REVIEW ON NANOPARTICLES FABRICATION AND THEIR APPLICATION

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ABSTRACT

Cyanobacteria have been recognized worldwide as the major source and its having many biological activities. In the present review reported optimization of phycobiliproteins production and its capability to synthesis nanoparticles. The growth and PBP production of organism were optimized by varying pH of growth medium, nitrogen sources, temperature, light quality and its ability to synthesis nanoparticles. The cell extract of cyanobacteria contains a vast array of active biomolecules that may facilitate synthesis and stabilization of the nanoparticles

Keywords: Cyanobacteria, Nanoparticles, Biomolecules, Phycobiliproteins

INTRODUCTION

Tropical country like, India has great diversity in its cyanobacterial resources that can be exploited at commercial level. But, research in the field of cyanobacterial phycobiliproteins is very nascent and need adequate attention. The prices of phycobiliproteins products are US$ 3 to US$ 25 mg-1 for native pigment but they can reach US$ 1,500 mg-1 for certain cross linked pigments (with antibodies or other fluorescent molecules). In the near future (next 5 years) its price are likely to grow by 20% annually **(Sekar and Chanramohan 2008)**. The National Center for Conservation and Utilization of Blue-Green Algae (NCCUBGA) at New Delhi (India) houses a large collection of heterocystous and non-heterocystous cyanobacterial strains from various agro-ecological habitats of the country. These PBSs are composed of pigmented phycobiliproteins (PBPs) and colourless linker polypeptides **(Glazer 1994; Sun *et al*. 2009a)**. The PBS has a core made up of allophycocyanin (C-APC) with rods of C-phycocyanin (C-PC), and sometimes phycoerythrin (C-PE) or phycoerythrocyanin (C-PEC) **(Singh *et al*. 2012)**. Each subunit of PBP contains one or more chromophores, phycourobilin (PUB), phycoviolobilin (PVB), phycoerythrobilin (PEB) and phycocyanobilin (PCB) linked to specific cysteines in apoprotein by thioether bonds **(Eriksen 2008)**. Cphycocyanin exists as a trimer from the aggregation of three alpha and beta (αβ) monomers, with a molecular weight of ± 232 kDa **(Patel *et al*. 2005)**, absorption of 620 nm and emission maxima of 640 nm **(Kuddus *et al*. 2013)**.

The major light harvesting pigments in cyanobacteria are chlorophyll-a (Chl a), carotenoids and phycobiliproteins **(Singh *et al*., 2009)**. Phycobiliproteins are found in cyanobacteria and some eukaryotic algal genera such as Rhodophyta (red algae) and Cryptophyta (flagellates). These are used as accessory or antenna pigments for photosynthetic light collection. Cyanobacteria can synthesize up to half of its total soluble protein **(Muramatsu and Hihara, 2012)**.

Cyanobacteria can regulate their tetrapyrrole content and composition in response to environmental signals, such as nutrient availability, light intensity, light wavelength and temperature **(Prassana *et al*. 2004)**. Natural colorants such as phycobiliproteins are gaining importance over synthetic ones, as they are nontoxic and non-carcinogenic. They are widely used in cosmetic industry and clinical/research laboratories as label for antibodies and receptors. Antioxidants, anti-inflammatory, neuroprotective and hepatoprotective properties are also exhibited by Phycobiliproteins **(Spolaore *et al*. 2006)**.

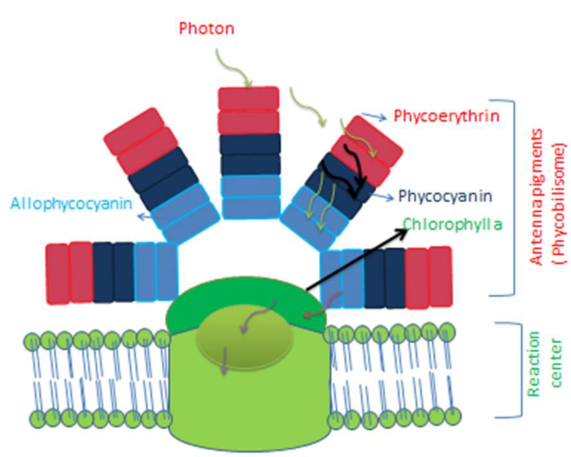

Figure 1: Structure of Cyanobacterial Phycobilisome

Phycocyanin (PC) is one of the important value added products which has been widely used for the benefit of the mankind. Blue color of PC imparts bluish color to many cyanobacteria. It is water soluble, strongly fluorescent and has antioxidant properties. PC and related phycobiliproteins are utilized in a number of applications in foods and cosmetics, biotechnology (fluorescent probes), diagnostics and medicine because of their antioxidant, anti-inflammatory, anti-viral, anti-cancer, cholesterol lowering, neuroprotective and hepatoprotective properties **(Rodríguez-Sánchez *et al.*, 2012; Spolaore *et al.*, 2006)**. The potential health benefits of phycocyanin may be because of its similarity with the chemical properties to the natural antioxidant, bilirubin **(Gantara *et al.*, 2012)**.

Bioactive compounds from cyanobacteria

Cyanobacteria have been found numerous compound that vital role in the biotechnological purpose **(Table 1)**. Researchers reported that cyanobacteria having particularly pigments gave important role in food cosmetics and pharmaceutical industries. Moreover, they comprise of protein, lipid and starch. Pigments like phycocyanin, phycoerythrin, lipid and biomass from cyanobacteria

Optimization of Cyanobacteria Phycobiliproteins production

The first requirement for any process development is to look for a high yielding strain and to identify the variables which influence on yield and to optimize conditions for higher yield. Optimization through statistical experimental design is a common practice in biotechnology **(Minocha *et al.*, 2007)**. **Table 3**.

Nitrogen source

Nitrogen limitation in *Oscillatoria* willei BDU 130511 resulted in the reduction of photosynthetic pigments such as chlorophyll a, carotenoids and phycocyanin resulting in chlorosis. It is known that in photosynthetic organisms N limitation triggers ordered degradation of phycobilisomes, ribosomes and thylakoid membranes **(Stevens *et al.* 1981)**. This explains the lowered pigment content, lipid content and change in pattern of fatty acids observed in O. willei BDU 130511 in this study as well as in Aphanocapsa 6308 **(Allen *et al.*, 1980)**, Agmenellum quadruplicatum **(Stevens *et al.* 1981)**. and Synechococcus 6301**(Wanner *et al.*, 1986)** by others. Studies have shown that cyanobacteria are able to assimilate a variety of nitrogen sources including ammonium (NH_4^+), nitrate (NO_3^-), nitrite (NO_2^-), urea, and amino acids with several species also capable of fixing N2 **(Herrero *et al.* 2001)**. However, comparatively few studies have investigated the effect of different nitrogen sources on growth and PBP content of cyanobacteria **(Choi *et al.* 2003; Rückert and Giani 2004; Flores *et al.* 2005; Simeunović *et al.* 2013; Deschoenmaeker *et al.* 2017)**. **Collos and Harrison (2014)** reported that the optimal ammonium concentration for Cyanophyceae was 3000 µM, whereas 13,000 µM concentration was toxic.

Temperature

Temperature is undoubtedly the most fundamental factor for all living organisms as it affects metabolic processes and biochemical composition of cells. The optimal growth temperature and tolerance to the extreme values usually vary from strain to strain. Sudden temperature changes exert stress on the organisms. At high temperature, deficiency of oxygen, which is much less soluble in hot than in cold water, may be the proximal cause of stress **(Brock 1978)**.

Photoperiod

Photosynthesis was taken light availability have been main source for maximum cells **(Ho *et al.*, 2017; Singh *et al.*, 2012)**. It was also reported that the proper adjustment of light-dark cycles strongly affected the energy efficiency of the production as well as phycocyanin productivity and content in *Spirulina platensis*, they were the highest in 30:30 (light-dark) cycle, respectively 101.1 $mg \cdot L^{-1} \cdot d^{-1}$ and 14.9% **(Ho *et al.*, 2018)**. **Chaneva *et al.*, 2007; Johnson *et al.*, 2014 reported** that cyanobacteria phycocyanin biosynthesis of was differ by depends on light intensity.

Light Quality

Light on its own plays a very important role in growth and pigment accumulation of cyanobacteria. Most cyanobacteria have the ability to control the amount of their photosynthetic antenna pigments, phycobiliprotein based on the spectrum of ambient light which is also known as chromatic adaptation **(Vogelmann and Scheibe, 1978)**. Upon exposure to changes in light colour or high irradiance, cyanobacteria dramatically change its pigmentation composition to optimize their light harvesting mechanism **(Grossman *et al.*, 2001; Ojit *et al.*, 2015)**. The changes in cell pigmentation in response to specific spectral illuminations is due to the moderation of the red colored phycoerythrin and the blue-colored phycocyanin, with a predominance of phycoerythrin in green-light-grown cells and of phycocyanin in red-light grown cells **(Paliwal *et al.*, 2017)**. Thus, even a slight fluctuation in light factors may lead to morphological and physiological changes in cyanobacteria.

Light quality is responsible to change the phycobiliproteins composition and colour through complementary chromatic adaptation (**Table 4**). The chromatic acclimation procedure allows the cells of cyanobacteria to change its light absorption characteristics to regulate photosynthesis according to light availability in different environments. As a result of this spectacle, the pigment which absorbs the incident wavelengths of light most strongly becomes predominant **(Wang *et al*., 2007)**. The present findings are also supported by the work done by **Ojit *et al*. (2015)**. In the contemporary findings, it was observed that white light was the suitable light source for the enriched production of Phycobiliproteins in the selected cyanobacterial strains investigated. According to Ojit *et al*. (2015) fluorescent white light was the most suitable light source for the enhanced production of phycobiliproteins in almost all cyanobacterial strains. In addition, their study also investigated that when strains were exposed to red light, their PE content decreased but simultaneously phycocyanin (PC) increased when compared to other light qualities. Similarly it was observed in PC rich cultures i.e. in red light, PC quantity decreased and PE production increased in blue light. The chromatic adaptation ability of cyanobacteria comprises of three complex pathway which includes regulation by a phytochrome class photoreceptor (highly responsive to green and red light), a complex two component signal transduction pathway and also reaction based on the redox state **(Paliwal *et al*., 2017)**.

Nanoparticles

In recent years, an increasing percentage of nanoparticles are emerging and making advancement in different fields. Nanoparticle play an vital role in drug delivery, diagnostics, imaging, sensing, gene delivery, artificial implants and tissue engineering **Morones *et al*., (2005). Sinha *et al*., (2009)** have reported that the biosynthesis of nanoparticles is advantageous over chemical and physical methods as it is a cost-effective and environment friendly method,

Nanotechnology, to create nanoparticles has particular function by combination of principles involving biology, physical and chemical **(Gnanajobitha *et al*., 2013: Suresh *et al*., 2011: Kumar *et al*., 2014; Mariselvam *et al*., 2014)**. Nano biotechnology is defined as a field that applies the nanoscale (with size in the range of 10–1000 nm) principle and techniques to understand and transform bio systems (living and non-living) and which uses biological principles and materials to create new devices and systems integrated from the nanoscale **(Mihail, 2003)**. An important area of research in nanotechnology is the biosynthesis of nanoparticles such as silver (Ag), gold (Au), palladium (Pd), mag- netite (Fe3O4), titanium (Ti), nickel (Ni), silica (SiO2), barium titanate (BaTiO3), cadmium sulfide (CdS), etc.

Among various nanoparticles which have found commercial applications, the silver nanoparticles find several applications, like antimicrobial, anticancer, optoelectronics, recording media, sensing devices, catalysis, medicine, semi conductors etc., Owing to extremely small size, silver nanoparticles exhibit enhanced properties when compared with the bulk material. This includes those having large surface area relative to their volume, ability to easily interact with other particles and increased antibacterial efficiency **(Sreeram *et al*., 2008)**. Silver nanoparticles are the metal of choice as they hold the promise to kill microbe's effectively. The silver nanoparticle act on a broad range of target sites both extracellularly as well intracellularly. In fact microbes generally have a harder time developing resistance to silver than they do to antibiotics. Silver nanoparticles take advantages of the oligodynamic effect that silver has on microbe, whereby silver ions bind to reactive groups in bacterial cells, resulting in their precipitation and inactivation **(Parashar, *et al*., 2009)**.

Synthesis of nanoparticles using cyanobacteria

Many researchers reported that different plants has been demonstrated successfully synthesis of metal nanoparticles Microorganisms typically live under ambient conditions of temperature, pressure, and acidity. Hence, they are the candidates for the development of manufacturing techniques that are more environmentally friendly than other, often hot, high-pressure and caustic processes.

Recognizing the importance of developing an eco-friendly synthesis of nanoparticles, an increasing number of researchers have turned to microorganisms such as the cyanobacteria, actinobacteria, bacteria, and fungi, which have shown an ability to reduce metal ions to form metallic nanoparticles.

Cyanobacteria are one of the largest and most primitive ancient groups of photoautotrophic prokaryotes on Earth **(Rippka *et al*., 1979)**. The synthesis of metal nanoparticles through biological routes has been practiced by several groups of workers **(Otari *et al*., 2014; Prasad *et al*., 2013)**. However, only very few reports are available regarding the use of cell extracts of bacteria/cyanobacteria for the synthesis of NPs **(Sharma *et al*., 2009; MubarakAli, *et al*., 2012) (Table 5) (Table 6)**.

Mechanism of AgNPs using Cyanobacteria extracts

Cyanobacteria cell extract is capable of reducing the $AgNO_3$ solution into AgNPs is not very well known **(Kedia *et al*., 2014)**, however, it is supposed that the enzyme, protein, amino acids and several other groups might be involved in the reduction of $AgNO_3$ solution into the AgNPs **(White *et al*.,2012)**. Some researchers state that a cyanobacterium having an enzyme called nitrate reductase is involved in the reduction of $AgNO_3$ into silver ion **(Ali DM *et al*., 2011)**. Singh *et al*., (2014) proposed that a number of cyanobacterial photosynthetic pigments and secondary metabolites such as phycobiliproteins, mycosporine-like amino acids (MAAs) and carotenoids are well known photoprotective compounds, present in the cell extract, which might be involved in the synthesis of AgNPs due to the diazotropic culture grown.

Table 1: Bioactive compounds from Cyanobacteria

Microalgae	Bioactive compounds	`Reference
Arthrospira platensis	Phycocyanin	Farzaneh *et al*., 2019
Euhalothece sp	C-phycocyanin	Mogany *et al*., 2018; Azimatun *et al*., 2019
Porphyridium purpureum	Phycoerythrin,	Xu *et al*., 2019: Hernández *et al*., 2019
Nostoc carneum	Phycoerythrin	El-Naggar *et al*., 2017
Chlorella pyrenoidosa	biodiesel	Bajwa *et al*., 2019
Dunaliella salina	protein	Kadkhodaei *et al*., 2015
Anabaena ambigua	Biomass	Venkata *et al*., 2015
Scenedesmus sp	Lipid	Fangfang *et al*., 2014
Ettlia sp	Lipid	Sungwhan *et al*., 2018
Synechocystis sp	Phycocyanin	Devendra *et al*., 2012
Navicula phyllepta	Biomass	Sabu *et al*., 2017
Phormidium ceylanicum	C-phycocyanin	Singh *et al*., 2009
Synechocystis PCC 6803	biomass, carbohydrate, and lipid production	Patel *et al*., 2014

Table 2: Application of Cyanobacteria for biomedical

Cyanobacteria	Control method (µg/mg dry weight biomass)	Optimized method (µg/mg dry weight biomass)	Reference
Anabaena fertilissima PUPCCC 410.5	383	696	Khattar *et al*., 2015
Nostoc muscorum	-	220	Ranjitha and Kaushik
Anabaena sp.	91	127	Fatma and Hemlata
Spirulina platensis	128	199	Ajayan *et al.*
Geitlerinema sulphureum	59	99	Manjushri and Anuja
Nostoc sp.	25	130	Johnson *et al.*
Spirulina platensis	86.3	12.33	Sharma *et al.*
Anabaena circinalis	202.46	–	Ojit *et al.*
Nostoc calcicola	-	16.78	Khojepour *et al.*

Table 3: Phycobiliprtein concetration of cynaobacteria growth in normal and optimized condition

Microalgae	Biomedical application	Reference
***Oscillatoria* sp.**	**Antibacterial, Antibiofilm potential and cytotoxicity**	**Bukola *et al*., 2019**
Oscillatoria limnetica	**Antibacterial and anticancer**	**Hamouda *et al*., 2019**
***Calothrix membranacea* KLR006**	**Antimicrobial**	**Ramya and Muralitharan, 2019**
***Desmodesmus* sp.**	**Antimicrobial**	**Öztürk *et al*., 2019**
Nannochloropsis	**Antibacterial, antibiofilm potential and cytotoxicity**	**Gnanakani *et al*., 2019**
Scenedesmus obliquus, Scenedesmus sp.	**Antibacterial**	**Osama *et al*., 2019 and Jayashree *et al*., 2014**
Nostoc carneum	**Antibacterial, antihemolytic, in vitro and in vivo cytotoxic activities**	**El-Naggar *et al*., 2018**
Trichodesmium erythraeum	**Antioxidant, drug-resistant bacteria, and cytotoxicity activity**	**Sathishkumar *et al*., 2019**
Phormidium sp.	**Antimicrobial activity**	**Rashed *et al*., 2018**
Nostoc linckia	**Antimicrobial activity**	**Vanlalveni *et al*., 2018**
Botryococcus braunii	**Antimicrobial activity**	**Arya *et al*., 2018**
***Nostoc* sp. HKAR-2**	**Antitumor, antibacterial and antifungal activities**	**Sonker *et al*., 2017**
Nostoc linckia	**In vitro anticancer activity and in vivo cytotxicity**	**El-Naggar *et al*., 2017**
Oscillatoria sp	**Antimicrobial activity**	**Sunil *et al*., 2017**
Chlorella vulgaris	**Antibacterial efficacy**	**Soleimani and Pirkooh, 2017**
Amphora SP	**Antimicrobial activity**	**Tevan *et al*., 2017**
***Spirulina* sp.**	**Antimicrobial activity**	**Muthusamy *et al*., 2017**
Spirulina platensis	**Antibacterial and anticancerous**	**Namasivayam *et al*., 2015**
Spirulina platensis	**Antimicrobial activity**	**Sharma *et al*., 2015**
Nostoc Commune	**Antifungal activity**	**Morsy *et al*., 2014**
Anabaena doliolum	**Antibacterial and Antitumor activity**	**Singh *et al*., 2014**
Scenedesmus abundans	**Antibacterial activity**	**Aziz *et al*., 2014**
Spirulina platensis	**Cytotoxicity activity**	**Rejeeth *et al*., 2014**
Chlorococcum humicola	**Antimicrobial activity**	**Jayashree *et al*., 2013**

Table 4: Light source on phycobiliproteins prodution by various cyanobacteria

Red light	**Cyanobacteria**	**PBP**	**Reference**
	Anacystis nidulans	**0.005 (μg/mg)**	**Rodriguez *et al*., 1991**
	Spirulina platensis	**3.389 (μg/mg)**	**Stowe *et al*., 2011**
	Synechococcus sp. NKBG	**-**	**Takano *et al*., 1995**
	***Calothrix* sp. (strain 7601)**	**-**	**Kilani J, Lebeault, 2007**
	Westiellopsis iyengarii	**-**	**Kumar *et al*., 2010**
	Synechococcus sp	**-**	**Elumalai wt al., 2014**
	Pseudanabaena sp.	**14.9 (μg/mg)**	**Mishra *et al*. 2012**
	Anabaena circinalis.	**14.9**	**Ojit *et al*., 2015**
	Nostoc sp.	**-**	**Poza *et al*., 2001**
	Nostoc muscorum	**-**	**Ranjitha and Kaushik, 2005**
White light	***Nostoc sp.***	**-**	**Eldin *et al*., 2014**
	Anabaena NCCU-9	**-**	**Fatma and Hemlata [33]**
Blue light	***Anabaena ambigua***	**-**	**Ramana *et al*., 2015Vijaya, and Narayanaswamy, 2009**
	Spirulina fussiformis	**-**	**Madhyastha and Vatsala, 2007**
	Nostoc sphaeroides	**-**	**Ma *et al*., 2015**

Table 5: Nanoparticles synthesis by microalgae and their biomedical application

Microalgae	Nanoparticles	Biomedical application	Reference
***Oscillatoria* sp.**	**Ag**	**Antibacterial, Antibiofilm potential and cytotoxicity**	**Bukola *et al*., 2019**
Oscillatoria limnetica	**Ag**	**Antibacterial and anticancer**	**Hamouda *et al*., 2019**
***Calothrix membranacea* KLR006**	**silver**	**Antimicrobial**	**Ramya and Muralitharan, 2019**
***Desmodesmus* sp.**	**silver**	**Antimicrobial**	**Öztürk *et al*., 2019**
Nannochloropsis	**Silver**	**Antibacterial, antibiofilm potential and cytotoxicity**	**Gnanakani *et al*., 2019**
Scenedesmus obliquus, Scenedesmus sp.	**silver**	**antibacterial**	**Osama *et al*., 2019 and Jayashree *et al*., 2014**
Nostoc carneum	**silver**	**antibacterial, antihemolytic, in vitro and in vivo cytotoxic activities**	**El-Naggar *et al*., 2018**
Trichodesmium erythraeum	**silver**	**antioxidant, drug-resistant bacteria, and cytotoxicity activity**	**Sathishkumar *et al*., 2019**
Phormidium sp.	**Silver**	**Antimicrobial Activity**	**Rashed *et al*., 2018**
Nostoc linckia	**Silver**	**Antimicrobial Activity**	**Vanlalveni *et al*., 2018**
Botryococcus braunii	**Silver**	**Antimicrobial Activity**	**Arya *et al*., 2018**
***Nostoc* sp. HKAR-2**	**silver**	**antitumor, antibacterial and antifungal activities**	**Sonker *et al*., 2017**
Nostoc linckia	**silver**	**in vitro anticancer activity and in vivo cytotxicity**	**El-Naggar *et al*., 2017**
Oscillatoria sp	**Silver**	**Antimicrobial Activity**	**Sunil *et al*., 2017**
Chlorella vulgaris	**Silver**	**Antibacterial Efficacy**	**Soleimani and Pirkooh, 2017**
Amphora SP	**silver**	**Antimicrobial Activity**	**Tevan *et al*., 2017**
***Spirulina* sp.**	**Silver**	**Antimicrobial Activity**	**Muthusamy *et al*., 2017**
Spirulina platensis	**silver**	**Antibacterial and anticancerous**	**Namasivayam *et al*., 2015**
Spirulina platensis	**Silver**	**Antimicrobial Activity**	**Sharma *et al*., 2015**
Nostoc Commune	**Silver**	**Antifungal activity**	**Morsy *et al*., 2014**
Anabaena doliolum	**Silver**	**Antibacterial and Antitumor Activity**	**Singh *et al*., 2014**
Scenedesmus abundans	**Silver**	**Antibacterial Activity**	**Aziz *et al*., 2014**
Spirulina platensis	**silver**	**Cytotoxicity activity**	**Rejeeth *et al*., 2014**
Chlorococcum humicola	**Silver**	**Antimicrobial activity**	**Jayashree *et al*., 2013**
***Nostoc* sp. EA03**	**zinc**	**Antibacterial, antibiofilm potential and cytotoxicity**	**Ebadi *et al*., 2019**
Lyngbya majuscula	**Gold**	**Anti-Myocardial Infarction**	**Esam *et al*., 2018**
Rhizocloniumsp.	**gold**	**Antimicrobial Activity**	**Parial *et al*., 2015**
Botryococcus braunii	**Silver and copper**	**Antimicrobial Activity**	**Arya *et al*., 2018**
Spirulina platensis	**Copper**	**Antibacterial activity**	**Saran *et al*., 2017**
Chlorella vulgaris	**palladium**	**Antibacterial activity**	**Farzaneh *et al*., 2017**
Chlorella vulgaris	**gold**	**Antimicrobial activity**	**Annamalai and Nallamuthu, 2015**
Synechococcus elongatus	**Silver and Gold Nanoparticles**	**Nil**	**Asmathunisha *et al*., 2018**
Anabaena variabilis	**silver nanoparticles**	**Nil**	**Hamed *et al*., 2017**
Euglena gracilis m	**gold nanoparticles**	**Nil**	**Dahoumane *et al*., 2016**
Chlorococcum sp.	**iron nanoparticles**	**Nil**	**Subramaniyam *et al*., 2015**

Table 6: Cyanobacterial extracts for nanoparticles synthesis and their characterization by UV, size of the NPs and zeta potential

Name of the cyanobacteria	Time of changing colour (h)	UV peak (nm)	Zeta Potential (mV)	Size of the NP (nm)	Reference
***Oscillatoria willei* NTDM01**	**72**	**450**	**NA**	**100-200**	**Mubarak Ali *et al*., 2011**
Spirulina platensis	**NA**	**430**	**NA**	**10–15**	**Mahdieh *et al*., 2012**
Anabaena doliolum	**72**	**420**	**NA**	**10-50**	**Singh *et al*., 2014**
***Arthrospira Indica* PCC7940**	**45**	**446**	**NA**	**NA**	**Husain *et al*., 2015**
***Nostoc* sp. HKAR-2**	**12**	**419**	**-1.80**	**51-100**	**Sonker *et al*. 2017**
Nostoc carenum	**24**	**430**	**-32.0**	**7.1–26.68**	**El-Ahmady *et al*., 2018**
Nostoc linckia	**8**	**435**	**NA**	**5–60**	**Vanlalveni *et al*., 2018**

CONCLUSION

In this review article, we deals with the phycobiliproteins from cyanobacteria with nitrogen sources, temperature, light condition for maximum phycobiliproteins and its capable of synthesizing various nanoparticles. Among that silver nanoparticles have been synthesized by various cyanobacteria reported by various researchers. Compared to other phycocyanin has been tremendous application towards the medical applications. So this review will helpful for understanding the phycocyanin deals with nanoparticles synthesis.

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