DOI :10. 13656/j. cnki. gxkx. 2004. 04. 022
广西科学 Guangxi Sciences 2004, 11 (4): 360362

A Review of Studies of *Porphyridium* sp. and Its Polysaccharide
紫球藻及其多糖的研究

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Abstract A review on researches and developments of polysaccharide in *Porphyridium* is revealed. The sulphated polysaccharide of *Porphyridium* sp. has impressive antiviral activity against the *Herpes simplex viruses* of types 1 and 2 (HSV1, 2) and *Varicella zoster* virus (VZV). The biological matter of this red microalga can be used to prevent the development of colon cancer in rats.

Key words *Porphyridium* sp., polysaccharide, antiviral activity

摘要 就近年来紫球藻生理活性物质中的硫酸酯多糖的研究进展作一综述. 紫球藻多糖具有抗病毒、抑制病毒复制, 对单疱疹病毒1型和2型(HSV1, 2)及水痘一带状疱疹病毒(VZV)有明显的抗性, 并可抑制小鼠癌细胞的发展.

关键词 紫球藻 多糖 抗病毒
中图法分类号 Q501; Q949. 9

1 *Porphyridium* sp.

Porphyridium sp. is a unicellular, photoautotrophic, and red microalga that has attracted much attention because of the economical and pharmaceutical importance of its polysaccharides and essential fatty acids[14]. In addition, the unicellular nature and the simplicity with which it can be cultured and manipulated have made it a useful experimental organism for studying photosynthesis and abiotic stress adaptations[5]. *Porphyridium* sp. is relatively stable over a wide range of temperatures (20160 ℃), pH values (210) and salinities[6]. Nevertheless, the photosynthetic system is prone to be damaged during mass culture. Under some conditions such as when the cells are exposed to continuous fluctuations in growth conditions such as temperature, light intensity, an increase in osmotics due to evaporation may damage the photosynthetic system and impair metabolic processes[7, 8].

Porphyridium was first described in 1849 by Naegeli, and named after its purple colour. Based on its colour, *Porphyridium* is considered to belong to porphyridiaceae, Porphyridiales, Bangiophycidae, Rhodophyta[5].

Porphyridium occurs in a diverse spectrum of habitats and has been isolated from marine, brackish, fresh water and soil as well as from the surface of moist in green houses[5]. The origin of *Porphyridium* as a marine alga was suggested by Pringsheim & Pringsheim due to its successful growth in natural seawater[9].

The cells are essentially non-walls, and extraplasmalemmal material is lack of skeletal or microfibrillar components[10]. Each cell has a single chloroplast, and the thylakoid membranes are covered with phycobilisomes. Carotenoids, viz., α-carotene, β-carotene, lutein and zeaxanthin are also found in red algae as accessory photosynthetic pigments. The cells are encapsulated within a gel-like form of sulfated polysaccharide complex[11].

2 Polysaccharides

Porphyridium sp. cells form capsules of sulphated polysaccharides around them. These extracellular polysaccharides have properties that may be applied in a variety of important end uses[12]. The polysaccharide of *Porphyridium* sp., which has a high apparent molecular mass of about 57×10^6 Da[13], is composed of about 10 difference sugars, among which xylose (38%), galactose (24%), and glucose (22%) represent the main momosugars, some minor sugars with protein, sulfate, and glucyronic acid. The latter two confer a negative charge on the polysaccharide[4]. Small amounts of methylated sugars (3-O-methyl-Xyl, 3-O-and 4-O-methyl-Gal, 2-O-methyl-GlcA)

2004-06-28 收稿。

have also been found[14]. The polysaccharide is anionic due to the presence of glucurnic acid[13, 15, 16] (about 10%) and sulfate half ester groups (about 7%), which are located mainly at the 6-and 3-positions of the glucose and galactose moieties[16]. Current study showed that the sulfate content of these biopolymers was increased to 35%40% by means of sulfation agents such as pyridine SO_3, *DMF* $\cdot SO_3$ and $ClSO_3H$[17].

Ramus[10] found that the capsules were thin in the logarithmic phase and became thicker in the stationary phase. These polysaccharides are water soluble. Accordingly to Ramus[10], the rate of production of the polysaccharide is higher than its rate of solubilization in the stationary phase. Vonshak[5] noted that it was the same polysaccharide that be bound to the cell wall and dissolved into the medium. The excretion of the polysaccharide creates an extracellular concentration gradient of polysaccharides with respect to the cell surface. Ramus[18, 19] found that the excretion of the polysaccharides was light independent, but depended on the other environmental factors. For example, the production of polysaccharide was found to increase under nitrogen starvation. Either sulfate or nitrogen starvation enhance the production and solubilization of polysacchride[20], and its chemical composition[21]. The source of sulfate, under such conditions, is from degradation of proteins such as phycoerythrin[20]. In addition, CO_2 concentration affects the production of cell wall polysaccharide, its composition and the proportion of bound and dissolved polysaccharide in the culture[22].

Several functions have been suggested for the capsular polysaccharides. They provide mechanical protection for the cell. They form impenetrable barriers to gases and water and protect the cells from desiccation. They may also create a buffer layer around the cells to protect them from extreme environmental conditions[4]. Furthermore, the polysaccharide may also serve as an ion exchanger or an ion reservoir[23, 24]. The polysaccharides adhere to cells into pseudoparenchymatous thalli, harhour vitamin and hormone producing heterotrophic microbes, and discourage the attachment of epiphytes[5]. The polysaccharides are highly viscous and are resistant to biodegradation. The polysaccharides have been already shown to exert biological activity. The polysaccharide of *Porphyridium* sp. has been found to be a good antioxidant[25], and to exhibit antiviral activity against *Herpes simplex* viruses (HSV 1, 2) and *Varicella zoster* virus[26]. The biological matter of this red microalga was found to prevent the development of colon cancer in rats[27].

Another interesting aspect of the polysaccharides of the red alga unicells is that they present biological properties with potential applications in medicine. Red microalgae are considered as a source of pharmacologically valuable polysaccharides[28]. These polysaccharides could be used as hypocholesterolemic or antiviral agents[29]. Potential pharmacological effects are expected in immune modulatory and antithrombotic activities. Another application was described as oral drug delivery matrix[30-33].

Reference

1 Bergé J P, Debiton E, Dumay J, et al. In vitro anti-inflammatory and anti-proliferative activity of sulfolipids from the red agla *Porphyridium cruentum*. J Agric food Chem, 2002, 50(6): 227-232.

2 Lapidot M, Raveh d, Sivan A, et al. Stable chloroplast transformation of the unicellular red alga *Porphyridium* species. Plant Physiol, 2002, 129: 712.

3 Huheihel M, Ishanu V, Tal J, et al. Activity of *Porphyridium* sp. polysaccharide against herpes simplex viruses in vitro and in vivo. J Biochem Biophys Methods, 2002, 50: 189200.

4 Arad (Malis) S. Polysaccharides of red microalgae. In: Cohen Z. Chemicals From Microalgae. London: Taylor and Francis Ltd, 1999. 282291.

5 Vonshak A. *Porphyridium*. In: Michael A. Micro-algal Biotechnology. Cambridge: Cambridge University Press, 1988. 123134.

6 Ucko M, Cohen E, Gordin H, et al. Relationship between the unicellular red alga *Porphyridium* sp. and its predator, the dinoflagellate *Gymnodinium* sp. Appl Environ Microbiol, 1989, 55: 2990-2994.

7 Carpentier R. Influence of high light intensity on photosynthesis: photoinhibition and energy dissipation. In: Pessarakli M. eds. Handbook of Photosynthesis. M Dekker Press, Arizona, 1996. 443450.

8 Foyer C H, Lelandis M, Kunert K. J Photooxidative stress in plants. Physiol Plant, 1994, 92: 696717.

9 Pringsheim E G, Pringsheim O. The growth requirements of *Pophyridium cruentum*: with remarks on the ecology of brackish water algae. Ecol, 1949, 37: 5464.

10 Ramus E. The production of extracellular polysaccharides by the unicellular red alga *Pophyridium aerugineum*. J Phycol, 1972, 8: 97111.

11 Gantt E, Conti S. The ultrastructure of *Pophyridium cruentum*. J Cell Biol, 1965, 16: 365381.

12 Geresh S, Arad (Malis) S. The extracellular polysacchride of red microalgae: Chemistry and Rheology. Bioresour Technol, 1991, 38: 195201.

13 Geresh S, Lupescu N, Arad (Malis) S. Fractionation and partial characterization of the sulfated polysaccharide of the red microalga *Porphyridium* sp. Phytochemistry, 1992, 31(12): 41814186.

14 Percival E, Foyle R A. The extracellular polysaccharides of *Porphyridium cruentum* and *Porphyridium aeruguineum*. *Carbohydrate Research*, 1979, 72: 165176.

15 Geresh S, Dubinsky O, Christiaen D, et al. Structure of 3-O-(alpha-D-glucopyranosyluronic acid)-L-galactopyranose, an aldobiouronic acid isolated from the polysaccharides of various unicellular red algae. Carbohydr Res, 1990, 208: 301305.

16 Lupescu N, Arad (Malis) S, Geresh S, et al. Structure of some sulfated sugars isolated after acid hydrolysis of the extra-

cellular polysaccharide of *Porphyridium* sp unicellular red alga. Carbohydr Res, 1991, 210: 349352.
17 Geresh S, Mamontov A, Weinstein J. Sulfation of extracellular polysaccharides of red microalgae: preparation, characterization and properties. Biochem Biophys Methods, 2002, 50 (23): 179187.
18 Ramus J. Cell surface polysaccharides of red alga *Porphyridium*. In: Loewus F (ed). Biogenesis of Plant Cell Wall Polysaccharides. New York: Academic Press, 1973. 333359.
19 Ramus J S. Algae biopolymer production. US Patent, 4, 236349.
20 Arad (Malis) S, lerental Y, Dubinsky O. Effect of nitrate and sulfate starvation on polysaccharide formation in *Rhodella reticulata*. Biores Technol, 1992, 42: 141148.
21 Ucko M, Geresh S, Simon-Berkovitch B, et al. Predation by a dinoflagellate on a red microalga with cell wall modified by sulfate and nitrate starvation. Mar Ecol Prog Ser, 1994, 104(3): 293-298.
22 Shi Yan L, Shabtai Y, Arad (Malis) S. Production and composition of the sulphated cell wall polysaccharide of *Porphyridium* (Rhodophyta) as affected by CO_2 concentration. Phycol, 2000, 39 (4): 332336.
23 Mariani P, Tolomio C, Braghetta P. An ultrastrutural approach to the adaptive role of the cell wall in the intertidal alga *Fucus virsodides*. Protoplasma, 1985, 128: 208217.
24 Ritchie R J, Larkum D V. Cation exchange properties of the cell-wall of *Enteromorpha intestinalis*. Exper Bot, 1982, 33: 125139.
25 Spitz T, Grossman S, Bergman M, et al. 2000-The Era of Biotechnology, 2000. Oct. 2427 2000, Beer Sheva (Abstract, p. 27).
26 Huheihel M, Ishanu V, Tal J, et al. 2000-The Era of Biotechnology, 2000. Oct. 2427 2000, Beer Sheva (Abstract, p. 34).
27 Shopen-Katz O, Ling E, Himelfarb Y, et al. 2000-The Era of Biotechnology, 2000. Oct. 2427 2000, Beer-Sheva (Abstract, p. 32).
28 Pulz O, Koehler E, Sandau P. In: The Proceedings of the International Symposium on Plant Polymeric Carbohydrates. Behr's: Hamburg, Germany, 1995. 137138.
29 Mahmoud H, Marina T, Yelena S, et al. Spectroscopic evalation of the effect of a red microalgal polysaccharide on Herpes-Infected Vero cell. Appl Spectrose, 2003, 57: 309395.
30 Huleihel M, Arad S. Effect of *Porphyridium* sp Polysaccharide on malignant cell transformation by Moloney murine sarcoma virus. Anticancer Res, 2001, 21: 20732078.
31 Dvir I, Chayoth R, Sod-Moriah U, et al. Soluble polysaccharides and cells of the red microalga *Porphyridium* sp reduce serum cholesterol and alter intestinal morphology in rats. Br J Nutri, 2000, 84: 469476.
32 Minkova K, Michailov Y. Toncheva-Panova T, et al. Antiviral activity of *Porphyridium cruentum* polysaccharide. 1996, 51(3): 19419 5.
33 Kolani R, Arad S, Kost J. The Proceedings of the International Symposium on Controlled Release of Bioactive Materials. 1995. 252253.

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54 刘起衔, 张灿明. 湖南杜鹃花属一新种. 植物分类学报, 1991, 29(3): 270271.
55 何明友, 朱　荃. 四川常绿杜鹃亚属一新种. 云南植物研究, 1996, 18(3): 295296.
56 何明友, 朱　荃. 四川杜鹃花一新种. 四川大学学报, 1995, 32(4): 477479.
57 何明友, 许介眉. 四川杜鹃花属新分类群. 植物分类学报, 1997, 35(1): 6366.
58 胡文光. 江西杜鹃花一新种. 四川大学学报, 1990, 27(4): 492494.
59 李光照. 广西杜鹃花属新分类群. 云南植物研究, 2001, 23 (3): 287290.
60 冯志坚, 吴志敏, 李镇魁. 广东杜鹃花科一新种. 华南农业大学学报, 1996, 17(1): 5960.
61 冯国楣. 云南杜鹃花新种和新变种. 云南植物研究, 1983, 5 (3): 265270.
62 杨汉碧. 杜鹃花科髯花杜鹃组两新种. 植物研究, 1989, 9 (1): 1720.
63 杨增宏. 云南杜鹃花属两新种. 植物分类学报, 1997, 35 (2): 186189.
64 Zhang changqin, D. paterson. Rhododendron maxiongense (Ericaceae), a New species from Yunnan. China. NOVON, 2003, 13: 156148.

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