影響Bacillus sp.DYU1菌株所生產之生物絮凝劑環境因子探討

陳永祥、吳建一

E-mail: 9607758@mail.dyu.edu.tw

摘 要

生物絮凝劑是一種天然高分子絮凝劑，具有無毒、安全、高效、可生物降解、無二次污染等特點，已被廣泛使用於廢水處理、食品與發酵工業以及自來水處理。生物絮凝劑DYU 300是由Bacillus sp. DYU1的發酵液所製備，具有良好之絮凝活性。本篇研究利用高嶺土懸浮液(kaolin suspension)為模擬對象，以探討絮凝劑DYU 300之絮凝能力。DYU 300之組成成分中，總糖、糖醛酸(uronic acid)、蛋白質及聚醯胺所占百分比分別為13.5%、3.4%、4.7%和48.7%。經傅立葉紅外線光譜(FT-IR)分析顯示，DYU 300具有羧基和胺基官能基團。而經絮凝試驗發現，絮凝活性、絮凝率及黏度會隨Bacillus sp. DYU1生長而增加，由此可知，生物絮凝劑DYU 300為菌株生長期間所生產。此外，實驗結果發現，添加二價金屬離子(Ca2+和Mg2+)於高嶺土懸浮液中可促進DYU 300的絮凝活性，而金屬離子的協同作用在酸鹼值pH 6-8範圍最為顯著。室溫下，添加40 mg-DYU 300/L及41.5 mM MgSO4至懸浮液中(pH 8)，可獲得最佳絮凝活性及絮凝率分別為19.5和97.4%。

關鍵詞 : 絮凝、生物絮凝劑、高嶺土、生物聚合物

目錄

參考文獻

1.張天送。2003。環境荷爾蒙—從限用塑膠袋說起，科學發展，370: 54-59. 2.Allen, M. M. 1984. Cyanobacterial cell inclusions. Annual Review of Microbiology 38: 1-25. 3.Allen, M. M., Hutchison, F. and Weathers, P. J. 1980. Cyanophycin granule polypeptide formation and degradation in the cyanobacterium Aphanocapsa 6308. Journal of Bacteriology 141: 687-693. 4.Anderson, A. and Dawes, E. 1992. Occurrence, Metabolism, Metabolic Role and Industrial Uses of Bacterial Polyhydroxyalkanoates, Microbiology Reviews 54: 450-472. 5.Baker, S. A. and Young, N. M. 1966. Isolation of hyaluronic acid by gel filtration on agarose. Carbohydrate Ressearch 2: 363-370. 6.Balazs, E. A. and Band, P. 1984. Hyaluronic acid: Its structure and use. Cometics and Toiletries 99: 65-72. 7.Bender, H., Rodriguez-Eatun, S., Ekanemesang, U. and Phillips, P. 1994. Characterization of metal-binding bioflocculants produced by the cyanobacterial component of mixed microbial mats. Applied and Environmental Microbiology 60: 2311-2315. 8.Bender, J., Archibold, E. R., Ibeanusi, V. and Gould, J. P. 1989. Lead removal from contaminated water by a mixed microbial ecosystem. Water Science and Technology 21: 1661-1665. 9.Bender, J., Gould, J. P., Vatcharapijarn, Y. and Saha, G. 1991. Uptake, transformation and fixation of Se (VI) by a mixed, selenium tolerant ecosystem. Water, Air and Soil Pollution 59: 359-367. 10.Birrer, G. A., Cromwick, A. M. and Gross, R. A. 1994. γ -Poly(glutamic acid) formation by Bacillus licheniformis 9945a: physiological and biochemical studies. International Journal of Biological Macromolecules 16: 265-275. 11.Borzi, A. 1887. Le comunicazioni intracellulari delle Nostochinee. Malpighia 1: 28-203. 12.Bovarnick, M. 1942. The formation of extracellular D(-)-glutamic acid polypeptide by Bacillus subtilis. The Journal of Biological Chemistry 145: 415-424. 13.Bruus, J. H., Nielsen, P. H. and Keiding, K. 1992 On the stability of activated sludge flocs with implications to dewatering. Water Research 26: 1597-1604. 14.Champney, K. J., Levine, D. P., Levy, H. B., and Leaner, A. M. 1979. Modified polyriboinosinic-polyribocytidylic acid complex:sustained interferonemia and its physiological associates in humans. Infection and Immunity 25: 831-837. 15.Chang, M. C., Chuang, S. H., and Lin, H. L. 1997. Effects of calcium ion on sludge conditioning. Water Science and Technology 35(8): 217-222. 16.Chibnall, A.C., Rees, M. W. and Richards, F. M. 1958. Structure of the polyglutamic acid from Bacillus subtilis. The

Biochemical Journal 68: 129-135. 17.Chitikela, S. and Dentel, S. 1998. Dual chemical conditioning and dewatering of anaerobically digested biosolids: laboratory evaluations. Water Environment Research 70: 1062-1069. 18.Dembinska, M. E. and Allen, M. M. 1988. Cyanophycin granule size variation in Aphanocapsa. The Journal of General Microbiology 143: 295-298. 19.Deng, S. B., Bai, R. B., Hu, X. M. and Luo Q. 2003. Characteristics of a bioflocculant produced by Bacillus mucilaginosus and its use in starch wastewater treatment. Agricultural and Biological Chemistry 60: 588 – 593. 20.Dubios, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A. and Smith, F. 1956. Colorimetric method of determination of sugars and related substances. Analytical Chemistry 28: 350-356. 21.Dugan, P. R. 1970. Removal of mine water ions by microbial polymers. Proceedings of the Third Symposium on Coal Mine Drainage Research. Pittsburgh (PA): Mellon Institute: 279-283. 22.Dugan, P. R. 1987. The function of microbial polysaccharide in bioflocculation and biosorption of mineral ions. In: Attia YA, editor. Flocculation in biotechnology and separation systems. Amsterdam: Elsevier: 337-350. 23.Dugan, R., in: Y.A. Attia (Ed.). 1984. Flocculation in Biotechnology and Separation System. Elsevier Science, Amsterdam: 337-351. 24.Endo, T., Nakamura, K. and Takahashi, H. 1976. Pronase susceptible floc forming bacteria: relationship between flocculation and calcium ion. Agricultural and Biological Chemistry 40: 2289-2295. 25.Esser, K. and Kues, U. 1983. Flocculation and its implication for biotechnology. Process Biochemistry 18: 21-23. 26.Esser, K., Hinrichs, J. and Kues, U. 1987. Genetic control of flocculation of yeast with respect to application in biotechnology. In: Attia YA, editor. Flocculation in biotechnology and separation systems. Amsterdam: Elsevier: 383-398. 27.Fattom, A. and SbBo, M. 1984. Phormidium J-l bioflocculant: production and activity. Archives of Microbiology 139: 421-426. 28.Friedman, B. A. and Dugan, P. R. 1968. Concentration and accumulation of metallic ions by the bacterium Zoogloea. Developments in Industrial Microbiology 9: 381-388. 29.Fujii, H. 1963. On the formation of mucilage by Bacillus natto. Part III. Chemical constitutions of mucilage in natto (1). Nippon Nogeikagaku Kaishi 37: 407-411. 30.Fujita, M., Ike, M., Tachibana, S., Kitada, G., Kim, S. M. and Inoue, Z. 2000. Characteristics of a bioflocculant produced by Citrobacter sp. YKF04 from acetic and propionic acids. Journal of Microbiology and Biotechnology 89: 40-46. 31.Golecki, J. R. and Heinrich ,U. R. 1991. Ultrastructural and electron spectroscopic analyses of cyanobacteria and bacteria. Journal of Microscopy 162: 147-154. 32.Gonzales, D., Fan, K. and Sevoian, M. 1996. Synthesis and swelling characterizations of a poly(γ -glutamic acid) hydrogel. Journal of Polymer Science. Part A, Polymer Chemistry 34: 2019-2027. 33.Guez-Eatun, S., Ekanemesang, U., and Phillips, P. 1994. Characterization of metal-binding bioflocculants produced by the cyanobacterial component of mixed microbial mats. Applied and Environmental Microbiology 60: 2311-2315. 34.Gutcho, S. 1977. Waste treatment with Polyelectrolytes amd other flocculants. Noyes Data Corp., Park Ridge, NJ: 1-37. 35.Hai, T., Oppermann-Sanio, F. B. and Steinbuchel, A. 1999. Purification and characterization of cyanophycin and cyanophycin synthetase from the thermophilic Synechococcus sp. MA19. FEMS Microbiology Letters 181: 229-236. 36.Hanby, W. E. and Rydon, H. N. 1946. The capsule substance of Bacillus anthracis. The Biochemical Journal 40: 297-309. 37.Hantula, J. and Bamford, D. H. 1991a. The efficiency of the protein dependent flocculation of Flavobacterium sp. Applied Microbiology and Biotechnology 36: 100 – 104. 38.Hantula, J. and Bamford, D. H. 1991b. Bacterial phage resistance and flocculation of Flavobacterium sp. Are phenotypically interrelated. Applied Microbiology and Biotechnology 36: 105-108. 39.Higgins, M. J. and Novak, J. T. 1997 The effect of cations on the settling and dewatering of activated sludges. Water Environment Research 69: 215-224. 40.Hiroaki, T. and Kiyoshi, K. 1985. Purification and chemical properties of a flocculant produced by Paecilomyces. Agricultural and Biological Chemistry 49: 3159-3164. 41.Houghton, J. I. and Quarmby, J. 1991. Biopolymer in wasterwater treatment. Current Opinion in Biotechnology 10: 259-262. 42.Huang, L. 1990. Studies on culture condition for production of flocculant by bacterial strain S-4K. Taiwan Tangye Yanjiu Huibao 129: 11 – 19. 43.Ike, M., Tachibana, S., Kitada, G., Kim, S. M. and Inoue, Z. 2000. Characterization of a bioflocculant produced by Citrobacter sp. TKF04 from acetic and propionic acids. Journal of Fermentation and Bioengineering 89: 40-46. 44.Ivanovics, G. and Bruckner, V. 1937. Chemische und immunologische Studien uber den Mechanismus der Milzbrandinfektion und Immunitat; die chemische Struktur der Kapselsubstanz des Milzbrandbazillus und der serologisch identischen spezifischen Substanz des Bacillus mesentericus. Z Immunitatsforsch Exp Ther 90: 304-318. 45.Kakii, K., Sugahara, E., Shirakashi, T. and Kuriyama, M. 1986. Isolation and characterization of a Ca2+ dependent floc-forming bacterium. Journal of Fermentation Technology 64: 57 – 62. 46.Kawai, T., Kubota, T., Hiraki, J. and Izumi, Y. 2003. Biosynthesis of ε -Poly-L-lysine in a cell-free system of Streptomyces albulus. Biochemical and Biophysical Research Communications 311: 635-640. 47.Khalil, M.I. and Aly, A.A. 2001. Preparation and evaluation of some cationic starch derivatives as flocculants. Starch/Staerke 53: 84-89. 48.Kunioka, M. 1997. Biosynthesus and chemical reactions of poly(amino acid)s from microorganisms. Applied Microbiology and Biotechnology 47: 469-475. 49.Kurane, R. and Matsuyama, H. 1994. Production of a bioflocculant by mixed culture. Bioscience, Biotechnology and Biochemistry 58: 1589 – 1594. 50.Kurane, R. and Nohata, Y. 1994. A new water-absorbing polysaccharide from Alcaligenes latus. Bioscience, Biotechnology, and Biochemistry 58: 235 – 238. 51.Kurane, R. and Nohata, Y. 1991. Microbial flocculation of waste liquids and oil emulsion by a bioflocculant from Alcaligenes latus. Agricultural and Biological Chemistry 55: 1127 – 1129. 52.Kurane, R., Hatamochi, K., Kakuno, T., Kiyohara, M., Hirano, M. and Taniguchi, Y. 1994a. Production of a bioflocculant by Rhodococcus erythropolis S-1 grown on alcohols. Bioscience Biotechnology and Biochemistry 58: 428 – 429. 53.Kurane, R., Hatumochi, K., Kakuno, T., Kiyohara, M., Kawaguchi, K., Mizuno, Y., Hirano, M. and Taniguchi, Y. 1994b. Purification and characterization of lipid bioflocculant produced by Rhodococcus erythropolis. Bioscience Biotechnology, and Biochemistry 58: 1977-1982. 54.Kurane, R., Toeda, K., Takeda, K. and Suzuki, T. 1986. Culture condition for production of microbial flocculant by Rhodococcus erythropolis. Agricultural and Biological Chemistry 50: 2309-2313. 55.Kwon, G. S., Moon, S. H., Lee, H. M., Kim, H. S., Oh, H. M. and Yoon, B. D., 1996. A novel flocculant biopolymer produced by Pestalotiopsis sp. KCTC 8637P. Biotechnology Letters 18: 1459-1464. 56.Lang, N. J. 1968. The fine structure of blue-green algae. Annual Review of Microbiology 22: 15-46. 57.Lawry, N. H. and Simon, R. D. 1982. The normal and induced occurrence of cyanophycin inclusion bodies in

several blue-green algae. Journal of Phycology 18: 391-399. 58.Lee, H. L., Lee, S. O., Jang, K. L. and Lee, T. H. 1995. Microbial flocculant from Arcuadendron sp. TS-49. Biotechnology Letters 17: 95-100. 59.Levy, H. B., Baer, G., Baron, S., Buckler, C. E., Gibbs, C. J., Iadarola, M. J., London, W. T. and Rice, J. 1975. A modified polyriboinosinic-polyribocytidylic acid complex that induces interferon in primates. The Journal of Infectious Diseases 132: 434-439. 60.Levy, N., Magdasi, S. and Bar-Or, Y. 1992. Physico-chemical aspects in flocculation of bentonite suspensions by a cyanobacterial. Water Research 26: 249 – 254. 61.Maeda, S., Kunimoto, K. K., Sasaki, C., Kuwae, A. and Hanai, K. 2003. Characterization of microbial poly (ε -L-lysine) by FT-IR, Raman and solid state 13C NMR spectroscpoies. Journal of molecular structure 655: 149-155. 62.MIchaels, A.S. 1954. Aggregation of suspensions by polyelectrolytes. Industrial & Engineering Chemistry 46: 1485-1490. 63.Naganishi, I., Kimura, K., Suzuki, T., Ishikawa, M., Banno, I., Sakene, T., and Harada, T. 1976. Demonstration of curdlan-type polysaccharide and some other β -1,3-glucan in microorganisms with aniline blue. The Journal of General and Applied Microbiology 22: 1-11. 64.Nakamura, J., Miyashiro, S. and Hirose, Y. 1976a. Conditions for production of microbial cell flocculant by Aspergillus sojae AJ7002. Agricultural and Biological Chemistry 40: 1341-1347. 65.Nakamura, J., Miyashiro, S. and Hirose, Y. 1976b. Screening, isolation and some properties of microbial cell flocculants. Agricultural and Biological Chemistry 40: 377 – 383. 66.Nakata, K. and Kurane, R. 1999. Production of an extracellular polysaccharide bioflocculant by Klebsiella pneumoniae. Bioscience, Biotechnology, and Biochemistry 63: 2064-2068. 67.Norberg, A. B. and Enfors, S. O. 1982. Production of extracellular polysaccharide by Zoogloea ramigera. Applied and Environmental Microbiology 44: 1231 – 1237. 68.Novak, J. T. and Haugan, B. E. 1981. Polymer extraction from activated sludge. Journal of Water Pollution Control Fed 53: 1420-1425. 69.Obst, M. and Steinbuchel, A. 2004. Microbial degradation of poly(amino acid)s. Biomacromolecules 5: 1166-1176. 70.Oh, H. M., Lee, S. J., Park, M. H., Kim, H. S., Kim, H. C., Yoon, J. H., Kwon, G. S. and Yoon, B. D. 2001. Harvesting of Chlorella vulgaris using a bioflocculant from Paenibacillus sp. AM 49. Biotechnology Letters 23: 1229-1234. 71.Oppermann, F. B., Pickartz, S. and Steinbuchel, A. 1998. Biodegradation of polyamides. Polymer Degradation and Stability 59: 337-344. 72.Oppermann-Sanio, F. B. and Steinbuchel, A. 2002. Occurrence, functions and biosynthesis of polyamides in microorganisms and biotechnological production. Naturwissenschaften 89: 11-22. 73.Perez-Camero, G., Congreado, F., Bou, J. J. and Munoz-Guerra, S. 1999. Biosynthesis and ultrasonic degradation of bacterial poly(γ -glutamic acid). Biotechnology and bioengineering 63: 110-115. 74.Pitman, A. R. 1975. Bioflocculation as means of improving the dewatering characteristics of activated sludges. Journal of Water Pollution Control Fed 74: 688-700. 75.Poiriner, Y., Dennis, D., Klomparens, S., Namrach, C. and Sommerville, C. 1992. Perspectives on the production of polyhydroxyalkanates in plants. FEMS Microbiology Reviews 103: 237-246. 76.Riley, F. L., Morin, M. L., Lvovsky, E., Stephens, E. E. and Levy, H.B. 1982. Polyriboinosinic-polyribocytidylic acid-poly-rlysine complex (Poly(ICL)) without carboxymethylcellulose (CMC): a new primate-effective interferon inducer (41329).Proceedings of the Society for Experimental Biology and Medicine 169: 183-188. 77.Roger C, Herdman. 1993. Biopolymers:Making Materials Nature`s way. U.S. Congress, Office of Technology Assessment. Washington, DC:U.S. Government Printing Office. 78.Salehizadeh, H., Vossoughi, M. and Alemzadeh, I. 2000. Some investigations on bioflocculant producing bacteria. Biochemical Engineering Journal 5: 39-44. 79.Senthilnathan, P. R. and Sigler, R. G. 1993. Improved sludge dewatering by dual polymer conditioning. Water Science and Technology 28(1): 53-57. 80.Shih, I. L. and Van, I. T. 2001. The production of poly-(γ -glutamic acid) from microorganisms and its various applications. Bioresource Technology 79: 207-225. 81.Shih, I. L., Van, Y. T., Yeh, L. C., Lin, H. G. and Chang, Y. N. 2001. Production of a biopolymer flocculant from Bacillus lichenformis and its flocculation properties. Bioresource Technology 78: 267-272. 82.Shima, S. and Sakai, H. 1977. Polylysine Produced by Streptomyces. Agricultural and Biological Chemistry 41: 1807-1809. 83.Shima, S. and Sakai, H. 1981. Poly-L-lysine Produced by Streptomyces.Part II . Taxonomy and Fermentation Studies. Agricultural and Biological Chemistry 45: 2497-2502. 84.Shimofuruya, H., Koide, A., Shirota, K., Tsuji, T., Nakamura, M. and Suzuki, J. 1996. The production of flocculating substances by Streptomyces griseus. Bioscience, Biotechnology, and Biochemistry 60(3): 498-500. 85.Simon, R. D. 1987. Inclusion bodies in the cyanobacteria: cyanophycin, polyphosphate, polyhedral bodies. In: Fay P, Baalen C van (eds) The cyanobacteria. Elsevier, Amsterdam: 199-225 86.Simon, R. D. and Weathers, P. J. 1976. Determination of the structure of the novel polypeptide containing aspartic acid and arginine which is found in cyanobacteria. Biochimica et Biophysica Acta. International Journal of Biochemistry and Biophysics 420: 165-176. 87.Sousa, M., Teixeira, J. and Mota, M. 1992. Difference in flocculation mechanism of Kluyveromyces marxianus and Saccharomyces cerevisiae. Biotechnology Letters 14: 213 – 218. 88.Stahl, U., Kues, U. and Esser, K. 1983. Flocculation in yeast, an assay on the inhibition of cell aggregation. Applied Microbiology and Biotechnology 17: 199 – 202. 89.Suh, H. H., Kwon, G. S., Lee, C. H., Kim, H. S., Oh, H. M. and Yoon, B. D. 1997. Characteristics of bioflocculant produced by Bacillus sp. DP-152. Journal of Fermentation and Bioengineering 84: 108-112. 90.Takagi, H. and Kadowaki, K. 1985. Poly galactosamine produced by a microorganism. Chitin Nat Technol 3: 121 – 128. 91.Takashi, A., Hayashi, S., Higashi, N., Niwa, M. and Kurihara, K. 2000. Charge regulation in polyelectrolyte brushes studied by FT-IR spectroscopy. Colloids and Surfaces A : Physicochemical and Engineering Aspects 169: 351 – 356. 92.Takeda, M., Koizhi; J., Matsuoka, H. and Hikuma, M. 1992. Factors affecting the activity of a protein bioflocculant pro-duced by Nocardia amarae. Journal of Fermentation and Bioengineering 74: 408-409. 93.Takeda, M., Kurane, R., Koizumi, J. and Nakamura, I. 1991. A protein bioflocculant produced by Rhodococcus erythropolis. Agricultural and Biological Chemistry 55: 2663-2664. 94.Tezuka, Y. 1969 Cation-Dependent flocculation in a Flavobacterium species predominant in activated sludge. Applied Microbiology 17: 222-226. 95.Toeda, K. and Kurane, R. 1991. Microbial flocculant from Alcaligenes cupidas KT201. Agricultural and Biological Chemistry 55: 2793-2799. 96.Unz, R. F. and Farrah, S. R. 1976. Exopolymer production and flocculation by Zoogloea MP6. Applied and Environmental Microbiology: 623-626. 97.Watson, D. W., Cromartie, W. J., Bloom, W. L., Heckly, R. J., McGhee, W. J. and Weissman, N. 1947. Studies on infection with Bacillus anthracis. V. The isolation of an inflammatory factory factor from crude extracts of lesions of B. anthracis infection and its

biological and chemical relationship to glutamyl polypeptide. The Journal of Infectious Diseases 80: 121-136. 98.Yokoi, H., Arima, T., Hirose, J., Hayashi, S. and Takasaki, Y. 1996a. Flocculation Properties of Poly(γ -Glutamic acid) Produced by Bacillus subtilis. Journal of Fermentation and Bioengineering 82: 84-87. 99.Yokoi, H., Natsuda, O., Hirose, J., Hayashi, S. and Takasaki, Y. 1995. Characteristics of a biopolymer flocculant produced by Bacillus sp. PY-90. Journal of Fermentation Technology 79: 378-380. 100.Yokoi, H., Shiraki, M., Hirose, J., Hayashi, S. and Takasaki, Y. 1996b. Flocculation properties of xanthan produced by Xanthomonas campestris. Biotechnology Techniques 10: 789-792. 101.Yokoi, H., Yoshida, T., Mori, S., Hirose, J., Hayashi, S. and Takasaki, Y. 1996c. Biopolymer flocculant produced by an Enterobacter sp. Biotechnology Letters 19: 569-573. 102.Yu, X. and Somasundaran, P. 1993. Enhanced flocculation with double flocculants. Colloids Surfaces A 81: 17-23. 103.Zajic, J. E. and Knetting, E. 1971. Flocculants from paraffinic hydrocarbons. Development in industrial microbiology. Washington (DC): American Institute of Biological Science: 87-98. 104.Zhu, X., Reed, B. E., Lin, W., Carriere, P. E. and Roark, G. 1997. Investigation of emulsified oil wastewater treatment with polymer. Separation Science and Technology 32: 2173-2187.