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Review on Eco-Friendly Construction Biotechnology

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Abstract: The biotechnologically produced materials and construction-related microbial biotechnologies have a lot of advantages over conventional construction materials and processes. Microbial cements, polysaccharides and construction bio plastics can be produced by using microbes.Construction biotechnology has immense benefits compared to conventional chemicals because of its eco-friendly, self healing nature and production from cheap renewable and recyclable materials. This review discuss about ecofriendly construction biotechnology.

Key words: Bio cement · Urease · Bio concrete · Bio plastic · Bio polymer

INTRODUCTION

Construction Biotechnology new field to develope ecofriedly construction materials like bio cement and bio concrete. The biotechnological production of construction biomaterials is a sustainable process because renewable agricultural and biotechnological biomass residues are used as organic raw materials and as the components of composite bio cement [1].

Microbial concrete has emerged as a new technique in recent years which can be used for various purposes. The “Microbial concrete” can be prepared by adding spore forming bacteria in the concrete that are able to continuously precipitate calcite, this process of production of calcite precipitation is called Microbiologically Induced Calcite Precipitation (MICP). One of the important construction material is microbial bioplastic, can be produced by using agricultural residuals and organic fraction of municipal solid wastes as a carbon source [2].

Biomaterials, which are used in construction, are industrially produced or in situ synthesized microbial polysaccharides. Polysaccharides such as xanthan, welan, succinoglucan, curdlan,chitosan are used in dry-mix mortars, wall plasters, self-leveling under layers, injection grouts to improve viscosity, water retention, set retarding and flow ability [2]. Eco friendly construction technology is a new technology to reduce pollution thus this review discussing the same.

Bacteria in Concrete Production: Bacteria from various natural habitats frequently been reported to precipitate calcium carbonate both in natural and in laboratory conditions. Different types of bacteria, as well as abiotic factors (salinity and composition of the medium) seem to contribute in a variety of ways to calcium carbonate precipitation in a wide range of environments [3].

Urease is a nickel dependent enzyme found in plants, bacteria and fungi that hydrolyses urea in to carbon dioxide and ammonia there by enhancing the pH of surrounding. Alkaline pH is the primary condition by which bacteria promote calcite precipitation. As a result of the negative charge or negative potential of the bacterial cell surface, calcium ions bond to the cell wall. If high concentrations of calcium ions are available close to the bacteria and carbonate ions are present in super-saturation level; precipitation of calcium carbonate crystals will occur on the bacterial cell wall [4].

The microbial concrete makes use of calcite precipitation by favourable bacteria. In this technique ureolytic bacteria (microorganism) are used hence the concrete is called Bacterial or Microbial concrete. The basic principle for this process is that the microbial urease hydrolyzes urea to produce ammonia and carbon dioxide and the ammonia released in surrounding subsequently increases pH, leading to accumulation of insoluble calcium carbonate [5].

Many organisms can use urea as a source of nitrogen by importing urea into the cell cytoplasm. One of the most robust ureolytic bacteria is *Sporosarcina pasteurii* an

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aerobic, spore forming and rod shaped bacterium. It uses urea as an energy source and produce ammonia which increases the pH in the environment.

The alkaline environment of concrete with pH around 12 is the major hindering factor for the growth of bacteria, so that more research has been focused on alkaliphilic microorganisms [4, 6, 7]. Mineralization of Calcium carbonate induced by microbes called as Biomineralization. Biomineralization processes of calcite induced by marine bacteria such as *Sporosarcina sp.*, *Bacillus sp.* and *Brevundimonas sp* [8]. Kartik and Gajjar [9], observed *Bacillus lentus* a common soil bacterium to induce calcite precipitation. As a result addition of bacteria (*Bacillus lentus*) in cracks improves the compressive Strength is around 17.3% at 28th day and 17.6% at 56th day.

Dhami *et al*. [3] investigated the potential of *Bacillus megaterium* to produce calcite and improve properties of Fly ash bricks and Rice husk ash bricks. They found that the treated bricks have considerably showed improved compressive strength and reduction in frost attack and water absorption. Kim *et al*. [10] studied the precipitation of calcium carbonate by microbes.

Algae in Bio Concrete and Biocement Production: Ariyanti *et al.* [11] studied the bio concrete production by using micro algae. Microalgae are a promising media to be used in biocementation, due to its photosynthetic metabolism. Algae's species like Spirulina, *Arthrospira plantensis* (Cyanophyta), Cruentum (Rhodophyta) basically are autotrophic microorganisms that live through photosynthetic process like *Chlorella vulgaris* (Chlorophyta), *Dunaliella salina*, *Haematococcus pluvialis*, *Muriellopsis* sp.,and *Porphyridium* which were used in bio cementation process [12, 13].

There are some advantages of using microalgae as media for bio cement production. Microalgae are type of renewable resources that easily cultivated rather than other type of microbe such as bacteria which already proved to be used in bio cementation, so that its availability as raw material can be maintained properly. It's easy to grow especially in tropical area, where many non-agricultural landfills can be utilized as a raceway pond for microalgae cultivation. Tropical country also has a good temperature and water with high mineral contained which is very suitable for microalgae cultivation. Another advantage is that the bio cement production using microalgae can reduce the CO_2 emission, which is produced in conventional cement production.

Biopolymer in Construction: Biopolymers such as wood, straw, bark, cactus juice, flour have been used as admixtures from ancient times to improve properties of mortars and plasters. Straw and cattle dung were used and are used even at the present time in rural construction as the com- posite biomaterials to improve construction properties of clay. The major application of microbial biopolymers in con-struction industry is addition to concrete and dry-mix mortars. Biodegradable microbial Welan gum and xanthan gum are used as building materials nowadays [2, 14]. Another application of microbial biopolymers is production of bacterial polysaccharides in soil to modify its geotechnical properties [15]. Some microbes are able to produce insoluble extracellular polysaccharides to bind the soil particles and fill in the soil pores.

Bacteria from genera *Acinetobacte*r, *Agrobacterium*, *Alcaligenes*, *Arcobacter*, *Cytophaga*, *Flavobacterium, Pseudomonas* and *Rhizobium* are potent to produce biopolymers [16, 17]. Chang *et al*. [18] studied the compressive strength by mixing of biopolymer with soil blocks (i.e., both 1% xanthan gum and 1% gellan gum).Chang and Cho[19,20]concluded that beta glucan treatment enhances the strength of natural soil with an increased ratio of up to 300–400% and also has low impact on the environment in terms of CO2 emissions. Chang *et al*., [21] observed the soil–biopolymer interactions and related soil strengthening mechanisms by microscopic studies.

Bio Plastics in Construction: Biodegradable plastics could be also useful for vertical drains, geo textile, geo membranes, soil stabilization mats. However, the cost of bio plastics produced aseptically in fermenters is usually several times higher than the cost of petrochemical-based plastics, so the reduction of the bio plastic production costs using cheap raw materials and technological innovations is essential.

Molasses is a sugar-rich co-product stream generated in sugar manufacturing industries [22]. In 2004, the global sugar production generated was about 39 million tons of cane molasses and 12 million tons of beet molasses. Molasses have been widely used as a carbon source in industrial scale fermentations due to its relatively low price and its abundance [23]. In 1992, Page [24] reported the production of polyhydroxybutyrate by *Azotobacter vinelandii* UWD using sugar beet molasses. Kalaivani and Sukumaran [25] had chosen agro industrial wastes molasses as the carbon source for PHA production from *Bacillus* sp. Khandpur *et al*. [26] observed that among the substrate used, sugarcane bagasse was the best substrate for the production of PHA with *Pseudomonas aeruginosa*.

Ceyhan and Ozdemir [27] demonstrated that the higher production of PHB observed when using Domestic waste water as a media from the bacteria *E.aerogenes*12Bi strain. All known methods of PHAs extraction suffer from a high cost or environmental pollution and are difficult to be industrialized. Therefore, crude bio plastic, without extraction of PHAs, could be used for construction applications. Major advantage of PHAs for construction applications is biodegradability of bio plastic to carbon dioxide and water for about 1.5 months in anaerobic sewage, 1.5 years in soil and 6.5 years in seawater [5].

CONCLUSIONS

Construction biotechnology includes microbial production of construction materials and microbially-mediated construction processes. Construction biotechnology is a safe economically feasible and eco friendly method. It can be used as one of the advance, reliable construction technology in this era.

REFERENCES

1. Ivanov, V., J. Chu and V. Stabnikov, 2015. Pacheco Torgal (eds.), Biotechnologies and Biomimetics for Civil Engineering. Eds., Pacheco Torgal, f.??? Springer International Publishing Switzerland. Make references like this style.
2. Plank, J., 2004. Application of biopolymers and other biotechnological products in building material. Appl. Microbiol. Biotechnol., 66: 1-9. Make references like this style.
3. Dhami, N.K., M. Sudhakara Reddy and A. Mukherjee, 2012. Improvement in strength properties of ash bricks by bacterial calcite. Ecol. Eng., 39: 31-35.
4. Fischer, S., J.K. Galinat and S.S. Bang, 1999. Microbiological precipitation of $CaCO_3$. Soilp Biol. Biochem, 31: 1563-1571.
5. Sunil Pratap Reddy, S., M.V. Seshagiri Raob, P. Aparnac and C.H. Sasikalac, 2010. Performance of standard grade bacterial (Bacillus subtilis) concrete. Asian. j. civil Eng (building and housing), 11(1): 43-55.
6. Kroll, R., 1990. Microbiology of extreme environments. McGraw-Hill. New York, pp: 55-92. Make references like this style.
7. Chahal, N., A. Rajor and R.Siddique,2011. Calcium carbonate precipitation by different bacterial strains. Afri. J. Biotechnol 10(42): 8359-8372.
8. Shiping Wei, Hongpeng Cui, Zhenglong Jiang, Hao Liu, Hao He and Nianqiao Fang, 2015. Biomineralization processes of calcite induced by bacteria isolated from marine sediments. Braz. J. Microbiol., 46(2): 455-464.
9. Kartik, M. and A. Gajjar, 2013. Study of Performance of Bacillus lentus on Concrete Cracks,, Ind. J. Res., 2(7): 71-74.
10. Kim, I.G., B.H. Jo, D.G. Kang, C.S. Kim, Y.S. Choi and H.J. Cha, 2012. Biomineralization-based conversion of carbon dioxide to calcium carbonate using recombinant carbonic anhydrase. Chemosphere, 87: 1091-1096. Make references like this style.
11. Ariyanti, D., N.A. Handayani and Hadiyanto, 2012. Feasibility of Using Microalgae for Biocement Production through Biocementation. J. Bioprocess Biotechniq, 2: 111-113.
12. Giordano, M., J. Beardall and J.A. Raven, 2005. CO2 Concentrating Mechanisms in Algae: Mechanisms, Enviromental Modulation and Evolution. Ann. Review Plant. Biol., 56: 99-131.
13. Chen, C.Y., K.L. Yeh, R. Aisyah, D.J. Lee and J.S. Chang, 2011. Cultivation, Photobioreactor Design and Harvesting of Microalgae for Biodiesel Production: A Critical Review. Biores. Technol., 102: 71-81
14. Ramesh, B.N.G., N. Anitha and H.K.R. Rani, 2010. Recent trends in biodegradable products from biopolymers. Adv Biotechnol., 9: 30-34.
15. Stewart, T.L. and H.S. Fogler, 2001. Biomass plug development and propagation in porous media. Biotechnol. Bioeng, 72: 353-363.
16. Portilho, M., G. Matioli, G.M. Zanin, F.F. de Moraes and A.R. Scamparini, 2006. Production of insoluble exopolysaccharide Agrobacterium sp. (ATCC 31749 and IFO 13140). Appl. Biochem Biotechnol., 129(132): 864-869.
17. Ross, N., R. Villemur, L. Deschenes and R. Samson, 2001.Clogging of limestone fracture by stimulating groundwater microbes. Water Res., 35: 2029-2037.
18. Chang, Minkyung Jeon and Gye-Chun Cho, 2015. Application of Microbial Biopolymers as an Alternative Construction Binder for Earth Buildings in Under developed Countries. Int. J. Poly. Sci., 1: 1-9.

19. Chang, I. and G.C. Cho, 2012. Strengthening of Korean residual soil with ◎◎-1,3/1,6-glucan biopolymer, Cons. Buil. Mat., 30: 30-35.
20. Chang, I. and G.C. Cho, 2014. Geotechnical behavior of a beta- 1,3/1,6-glucan biopolymer-treated residual soil," Geomech. Eng., 7(6): 633-647.
21. Chang, I., Jooyoung Im and Gye-Chun Cho, 2016. Introduction of Microbial Biopolymers in Soil Treatment for Future Environmentally-Friendly and Sustainable Geotechnical Engineering. Sustain, 8: 251-271.
22. Albuquerque, M.G.E., M. Eiroa, C. Torres, B.R. Nunes and M.A.M. Reis, 2007. Strategies for the development of a side stream process for polyhydroxyalkanoate (PHA) production from sugar cane molasses. J. Bio. Technol., 130: 411-421.
23. Zhang, H., V. Obias, K. Gonyer and D. Dennis, 1994. Production of polyhy- droxyalkanoates in sucrose-utilizing recombinant Escherichia coliand Klebsiella strains. Appl Environ Microb., 60: 1198-205.
24. Page, W.J., 1992. Production of polyhydroxyalkanoates by Azotobacter vinelandii UWD in beet molasses culture. FEMS Microbiol. Rev., 103: 149-157.
25. Kalaivani, R. and V. Sukumaran, 2015. Enhancement of Technique for Optimized Production of PHA from Marine Bacteria, Utilizing Cheaply Available Carbon Sources at Thanjavur District, India Int. J. Curr. Microbiol. App. Sci., 4(4): 408-417.
26. Khandpur, P., E.T. Jabeen, K.V.L. Rohini, Y. Varaprasad and B. Laxminarayana, 2012.Study on Production, Extraction and Analysis of Polyhydroxyalkanoate (PHA) from Bacterial Isolates. IOSR J Phar.Biol. Sci. 1(1): 31-38.
27. Ceyhan, N. and G. Ozdemir, 2011. Poly--hydroxybutyrate (PHB) production from domestic wastewater using Enterobacter aerogenes 12Bi strain. Afri. J. Microbio. Res., 5(6): 690-702.