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General Overview of Previous Advances on Polyhydroxyalkanoates (PHA) Synthesis by Microorganism Utilizing Different Waste Carbon Sources

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ABSTRACT

This review paper denotes recent advances of Polyhydroxyalkanoates (PHA), derived from bacterial fermentation of sugars or lipids. Polyhydroxyalkanoates (PHA) are biodegradable polyesters, (PHA) has many hydroxyl groups depend on carbon sources. This study gives overview of recent research dealing with PHA synthesis, utilizing various carbon sources producing biodegradable polymers, degrading of PHA by microorganism to water and carbon dioxide found in soil, sewage and water, therefore, PHA Production increased under salty medium such as sodium chloride, bioplastic was characterized by FTIR, DSC, TGA, and NMR. recent studies on contaminant treatment, tissue engineering and fermentation strategies can give comprehension for researchers to design production of bioplastics from waste carbon sources. Also cost effective PHA synthesis, this review explores beneficial information about the limit affiliate with the tolerable PHA synthesis utilizing different waste carbon sources. various great advances have been generated: different wastes as raw material, various extraction pathways, and meet design of bioplastic. This review paper resumed the scientific and technological improvement of PHA through their discovery in 1888 up to their recent applications and most current commercial utilization.

Keywords- Polyhydroxyalkanoates (PHA), Biodegradable, microorganism, salt medium.

I. INTRODUCTION

The collection of synthetic oil plastic waste in the environment is dangerous rising problem. Therefore, to find alternative chemicals, researchers have made fully biodegradable bioplastics, like polyhydroxyalkanoates (PHAs) extracted from microorganism cells, explore chemical properties that are same to polypropylene (pp) [1]. according to the estimation in 1930 the plastic production in the world reached to 23000 tones, in the year after world war the production of plastic reached minimum 1.3 million tons, in 1993 it was estimated that production of plastic annual reached to 100 million tones, western countries used 430 kg per years [1]. production of poyhydroxyalkanoates (PHAs) utilizing agriculture waste, low price raw material like rice bran and Isolation and screening of PHA producing bacteria from good source of sugar waste and also to reduce the cost of polyhydroxyalkanates at commercial level [2].

Study showed that biosynthetic polymer PHA that could be degradable after use much important for biodegradable plastic, according to study the effect of environmental factor and structure of PHAs associated with PHA synthesis by the intracellular microorganisms fermentation related to their raw materials used to utilize energy when extraction process occur, and restricting their possibility for trade, however, this study explained the usage of industries waste water for valorization of PHA extraction [3]. various type of production of biomass and PHA obtain after fermentation, the bacteria which is selected for this study was *Cupriavidus necator* H16 because it has completed genetic profile, robustness,

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stability and can produce PHA at low temperature, the production of PHA was various from 39% pro degraded up to having nitrogen rich media 48% (w/w) of treated with biomass [4].

different aspect of metabolism occurred for PHA biodegradable polymer that contain effect of Temperature, thermal degradation, hydrolytic degradation, presence of water, photo degradation through microorganisms, study showed that degradation of small molecular weight take less time but degradation of large molecular weight of PHA take more time and combustion by light and analysis of hydrolyzing there functional group in environment, as mentioned degradation of PHA occurred by two different pathway one was extracellular and another was intracellular degradation by the de polymerases enzyme and PHA hydrolyases enzyme, However, the degradation time of pieces of PHA depending on the plastic composition and environmental condition, range of time maybe from a few month to years [5].

II. HISTORY OF POLYHYDROXYALKANOATES (PHA)

Beijerinck was the first person to report about PHAs in 1888, The first example of Polyhydroxyalkanoates granules within bacterial cytosol and discovered the Polyhyroxybutyrates (PHB) in the year 1926 by Maruice Lemolgne [6].

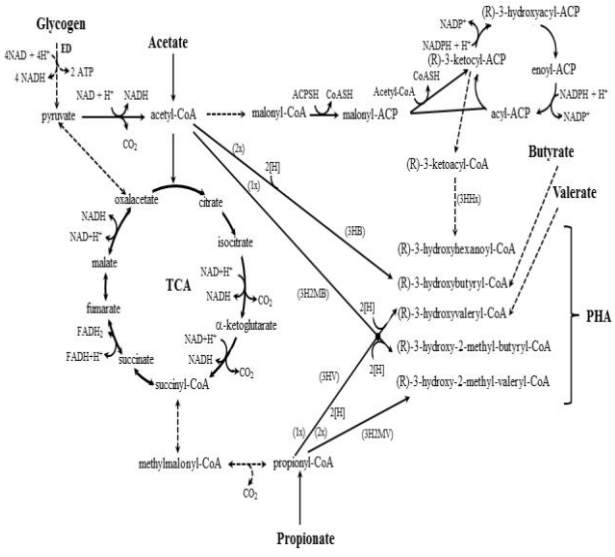

Fig. 1: Biosynthesis of PHA Production

III. APPLICATION AND PROPERTIES

Environmentally friendly polymers of polyhydroxyalkanoates (PHAs) naturally generated by various microorganism aggregate as energy store under abundant carbon, and limiting nitrogen sources, however, bacterial isolates form dairy sewage, local mess food, oil wastes, oil dipped cloth, and few type cultured in suitable mediums were screened for polyhydroxyalkanoates production, approximately bacterial isolated from oil dipped cloth have maximum concentration of polyhydroxyalkanoates synthesis, and it was later recognize as (*bacillus cereus*) by 16S rDNA analysis technique.

Characterization and bioproduction of medium chain length Polyhydroxyalkanoates (mcl-PHAs synthesis by *Pseudomonas putida* Bet001 obtain from palm oil mill issuant was studded, however, bio production of medium chain length (mcl-PHAs) by 12 the *Pseudomonas putida* Bet001 follows a growth associated attitude, Accumulation of medium chain length (mcl-PHAs) ranging from 49.7 to 68.9% on cell dry weight (CDW) bases were observed when fatty acid ranging from octanoic acid (C8:0) to oleic acid (C18:1) were used as sole carbon and energy source [7].

Studies showed that the application of biodegradability and properties of polyhydroxyalkanoates (PHAs) at various industrial and biomedical utilizing due to their biodegradability, resorb ability, compatibility, and piezoelectricity, however study showed that several bacteria species accumulating PHA compound, these bacteria can be isolated from different industrial waste material, *Pseudomonas genus* of bacteria are famous to accumulate PHA in presence of carbon source and suitable medium, so these bacteria is fed to fatty acid it passes through the beta oxidation biosynthetic process, to produce PHAs, therewith losing two carbon atom per each cycle, various published word use unsaturated carboxylic acid such as oleic acid to produce mcl-PHAs with a side chain of unsaturated monomer of organic acid [8]

According to the bio polyester bonding density and special hydrophobic specification at surface of bio polyester crystal and adsorption of many enzymes on the surface of crystal depend to the amount of ester bond rather than the hydrophobicity of the surface, Similarly, attaching of PHA depolymerase enzyme to the polyester part of aliphatic, but not only hydrophobic reaction but also particular interaction between attaching domain and poly ester bond. dissociation speed of PHA de polymerase by the enzymatic interaction of (3PHA) is dependent to PHB crystalline state, particularly contain PHA reaction state, concentration and properties of de polymerase enzyme, however, when the concentration of de polymerase enzyme get increased enzymatic hydrolysis reaction also get rise, study showed that any molecule of PHA on the film surface of (3PHB) adsorbed irreversibly on the crystal. Finally, divided in solution through the binding of de polymerase enzyme [9].

IV. PHA EXTRACTION

Almost 3.5 mg of dried plant-based material or 5.0 mL of re-suspended samples (dried and wet thermally treated biomasses) were suspended in 2 mL of acidify methanol solution (at 3% w/v H_2SO_4) having benzoic acid

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(at 0.005% w/v) as internal standard and 1 mL of chloroform in a screw-capped test tube. Then, an acid-catalyzed metanalysis of the PHA happened and the liberated methyl esters were measured by gas-chromatography (GC-FID Perkin Elmer 8410) method described in [6]. The related plenty of 3HB and 3HV monomers was specified using a traditional P(3HB-co-3HV) biopolymer with a 3HV content of 5 wt. % [9] as reference standard. The 3HV content in PHA was calculated as the ratio of 3HV and (3HV + 3HB) monomers (as wt. %). method described in [8]. The related abundance of 3HV and 3HB monomers was specified using a traditional P(3HV-co-3HB) biopolymer with a 3HB content of 5 wt. % [6]. The 3HV content in PHA was measured as the ratio of 3HV and (3HV + 3HB) monomers (as wt. %) [9].

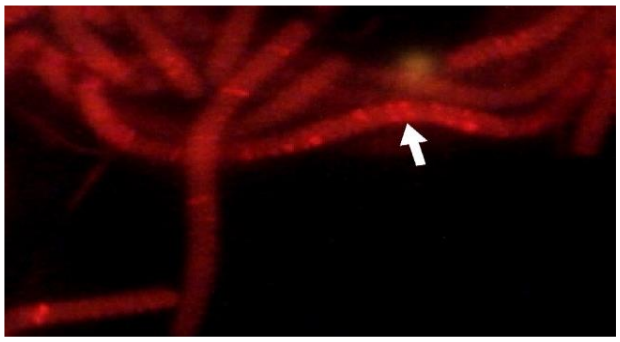

Fig. 2: S. subsalsa cells on Nile red stained containing PHA polyester.

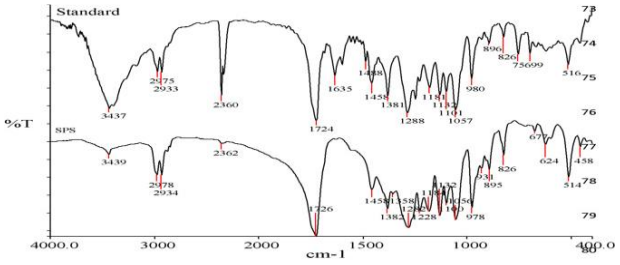

Fig. 3: PHA FTIR spectra from S. subsalsa (SPS), compared with standard PHB [2].

The trinary mixture, in which the PHV biopolymer mixture was mixed with mcl-PHA and epoxide cardoon oil, testified a synergic effect ion of both additives in formulating PHB polymer structure and thermic properties, elevated by the physical interaction happening among the ingredient. This proof-of implication frames the article in the holistic accede of circular economy applied to biopolymer extraction [10].

The Great requirement for sustainability on the application of biopolymer opens a modern opportunity for a numerous of bioplastic that are produced in bacterial processes. Over the last decades, major attention has been concentrated on polyhydroxyalkanoates (PHAs), biodegradable polymers with plasticity properties. The focus of this specific Issue is to highlight the most current advances in the bacterial synthesis of PHAs. It addresses multiple determine appearance of the PHA synthesis chain relevant to the advances and formulated of modern bioprocesses towards the betterment of PHAs production, explanation of microorganism as PHAs producers of industrial interest, molecular design of polymers with a variety of properties, solutions to decrease overall production costs of microbial PHAs [11]. Organic expletive and fibers made of cellulosic substance can make better the properties of biopolymers, therefore, effect on the maritime biodegradable compound matrix properties remains an unexplored area. several possible compositions of environmentally friendly polymers, fillers and their effect on the biodegradation of PHA-based bio compound are a wide unexplored territory. The potential interest of PHA-based bio composites creates a strong case for future research into this scope [12].

Recent reviews explore the Previous improvement in scl-PHAs, but there is limited study Particularly focused on the growth of mcl-PHAs. therefore, this study focused on the mcl-PHA synthesis, utilizing different carbon sources (organic/inorganic) and at various technical method (continuous, batch, fed-batch, and high-cell density (HCD)). This study also focused on previous developments on extraction techniques of mcl-PHAs (different solvent, various non-solvent, different enzymatic, ultrasound); physical and thermal properties (Mw, Mn, PDI, Tm and crystallinity); applications in different area; and their production at commercial and industrial scales in Asian countries, Australia, North and south America [13]. Modification of metabolic pathways for PHA Synthesis utilizing modern extrude techniques like CRISPR/Cas9 technology has made easier the process Passing less amount of time.

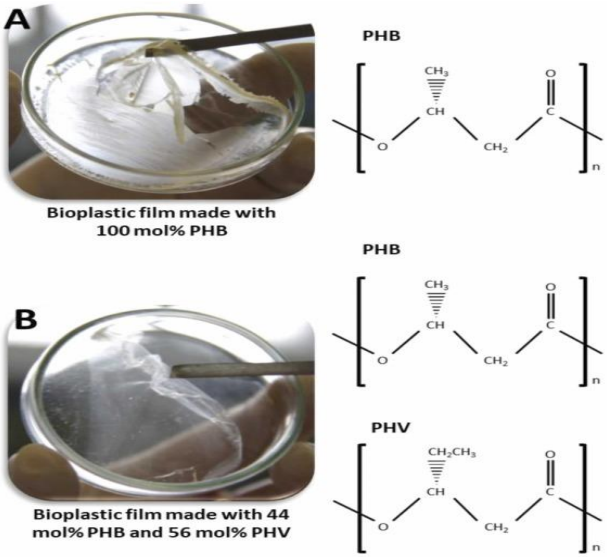

Fig. 4: various kind of Polyhydroxyalkanoates PHA-based biopolymer generate under the similar experimental conditions but with various monomer dissociation. Fig. A explore clear pure PHB and Fig. B denote a brit film made by 56 mol% PHV and 44 mol% PHB [16].

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Green solvents under pressurized state, different ionic liquids, various supercritical solvents, hypotonic cell dissociation and release of PHA Bioplastic, various anionic surfactants and digestion of non-PHA bio chemicals by microorganism and animals are some modern strategies for PHA improvement which play an effective role in tolerable synthesis of PHA. However, this study provides a overview of previous applications, importance of PHA and new techniques used for its extraction which are lacking in the accessible literature [14].

We have carried out an impartial search of up-to-date literature to disclose towards topics in the research of PHAs over the last four decades by mining data of 2,227 publications. Identification of last different extraction of PHA and going trends in this Scope. Our review provides a Great study on these trends and theorize where PHA research is superscription [15].

V. CONCLUSION

The bioavailable polymer of PHAs has creates its application not just enough to biodegradable but it has now been used in different areas such as tissue engineering, medicinal application, plastic bag, washing cream, surgery wire, and agriculture tools. improvements in chemical engineering strategies have significantly greater increased the area of study in various microorganisms for PHA production. new carbon resources certify the sustainability of the PHA synthesis. The use of agriculture waste, different enzymes, different ionic liquids, different anionic solution of PHA easier and environment friendly. All these advanced methods provide more area to a researcher to select suitable methods considering its environmental possibility and cost efficiency without concessions its degree of pureness and molecular weight. Therefore, this review made a wide view of different methods recently used by researchers for cost-efficiency and beneficial synthesis of PHA, that could be also helpful in further improvement of the present methods with respect to further perspective of this environment friendly Polymer. therefore, it is reliable that in the upcoming future if cost efficiency of raw materials and economic extraction methods are used, market demand of PHA Production would be increased consequently and would chip in towards getting a synthetic plastic free environment. Polyhydroxyalkanoates PHA are a Great well alternative to oil-based synthetic plastics but still away to displace them mostly due to their great costly production and lack of particular policies.

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