

## Bio-Plastic production from vegetable (Potato) starch and conc. Corn syrup

Deepa lakshmi.M ,Rajeswari Hari\*

Dr.M.G.R Educational And Research Institute Deemed to be university Chennai-95.Tamil Nadu. India

Rajeswari Hari\*

Head Of The Department Department of Biotechnology Dr.M.G.R Educational And Research Institute Deemed to be university Chennai-95.Tamil Nadu. India

Corresponding Author Rajeswari Hari\*

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### Abstract

#### Background:

The increase in population across the globe and the resulting increase in commodities have led to huge demand for variety of materials for various applications. One of the important material that has become an inevitable utility is plastic and its hazard caused to our environment. Bio-plastics help to reduce the dependency on petroleum based polymers and acts as a better servement in controlling the emmission of CO<sub>2</sub> in atmosphere. The disadvantages and consequences of handling plastic always lead the scientist in questioning the alternate bio degradable, non-hazardous, eco-friendly material. In view of this, an attempt is made to synthesize plastic through a natural source of ingredient starch . The so produced bio-material will be utilized to replace the toxic plastic and reduce the cumbersome task in decomposition. Bio-plastic is synthesized from potato starch and corn syrup. In order to synthesize bioplastic from vegetable starch, some preliminary experiments were conducted to determine the adequate proportion of ingredients. The production of plastic requires a polymer (starch), a plasticizer (conc. corn syrup), a solvent (water) and an acid (vinegar) . The yield is a flexible , dense polymer which can be used for several applications in a daily life.

**Materials and Methods:** Potatoes are bought from the nearby vegetable shop. Recrystallized starch was prepared by heating granular starch in de-ionozed water (10%) for 3 hours at 95°C. 0.1% sodium azide was added and the mixture was stored at room temperature for approximately one year. Then gels were subjected to drying by evaporation till the water content was reduced to 13.5% . Dried starches with less than 1% water content was obtained by granular drying.

**Result:** The yield was subjected to drying and then removed from the mould and examined for its characteristics . The product is exposed to high temperature. It is found that at high temperature exposure is satisfactory and the material becomes charred. The thickness and firmness of the product are observed and appreciable. The product also has elasticity such that the experiment conditions can be modified to synthesize thin firm for the application in manufacturing of raincoats, bags and packaging materials.

**Conclusion:** The bio-plastic is been synthesized from potato starch which is a natural source. On comparison of both the materials made from different starch materials, the material from potato starch seems to be a very good alternative to non-degradable polymer. The manufacturing of bio- plastics is definitely an additional advantage of renewable resource for the synthesis and there is no oil based component or trees to be cut off.

**Key words:** Bio-plastic, potato starch , conc.corn syrup, polylactic acid, plasticizer.

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### I. Introduction

Plastic is material consisting of a wide range of synthetic or semi-synthetic organic compounds and are one of the most valuable materials because of their extra-ordinary versatility and also due to low cost . They are typically organic polymers of high molecular mass . They are usually synthetic, most commonly derived from petrochemicals, however, an array of variants are made from renewable materials such as polylactic acid from corn or cellulosis from cotton liners. The poly lactic acid (PLA) is one of the most commercially available and exploited bio-plastics. In a more recent development, polyethylene, a non-bio-degradable polymer has also been made from bio-ethanol fermented from sugar.

Bio-plastic refers to plastic made from plant or other biological material instead of petroleum, from renewable biomass sources and are used as disposable items such as packaging grocery, cutlery pots, bowls and straws. It is also often called bio-based plastic .Usually they are derived from sugar derivatives including starch,

cellulose and lactic acid. As of 2014, bio plastics represent approximately 0.2% of the global polymer market. Though bio-plastics analysis are not included recently, they will be implemented in future.

Nowadays, there is great interest in the utilization of starch as a renewable resource in the production of ethanol and plastics. It has been found that starch constitutes a rich resource of fermentable sugars to produce fuel ethanol ( Sanchez and Cardona 2008).

Generally Plastic processing begins by mixing, shaping and finishing. These can be performed by certain instruments such as: Mixers , Blenders , Pulverizers. Incineration of plastic will contribute greenhouse gases in the equivalent of 850 million tonnes of carbon dioxide (CO<sub>2</sub>) to the atmosphere. A unique feature of bio-plastics is that, unlike most conventional plastics, the post-use materials may be treated biologically, e.g. via aerobic composting, to generate carbon and nutrient rich compost as a soil improver. The composting of bio-plastics may be carried out with organic wastes either in industrial compost (or municipal) or home compost (or domestic/garden/backyard). Compost can be used as soil enhancer to enhance water retention and increase the availability of water to plants. This has led to the establishing of different standards and certification systems to regulate the composting practices.

## **II. Objective of the research:**

Utilization of vegetable waste such as potato starch and conc. Corn syrup for the production of biodegradable plastic. Conc.corn syrup is considered for the production instead of gelatin in order to reduce the utility of hazardous plastic. In view of this, an attempt is made to synthesise plastic through a natural source of ingredient starch to produce a bio-material that will be utilized to replace the toxic plastic and reduce the cumbersome task in decomposition. Thus a non-hazardous, eco-friendly environment can be created .

## **III. Materials And Methods**

The commercially available potatoes were used in the present study which were bought from near by vegetable shop. Recrystallized starch was prepared by heating granular starch in de-ionized water (10%) for 3 hours at 95°C. 0.1% sodium azide was added and the mixture was stored at room temperature. Then gels were subjected to drying by evaporation till the water content was reduced . Water acts as a solvent to dissolve the starch and secondly helps the starch molecules to stay disrupted after heating. Glycerol was mixed with water and starch to confirm that the yielded plastic was flexible but not too soft.

### **(A) Preparation Of Potato starch:**

Potatoes are bought from the nearby vegetable shop. .Potato starch is a commercial product consisting of 79% amylo-pectin and 21% amylose. Potato are used to extract the starch. Recrystallized starch was prepared by heating granular starch in de-ionized water (10%) for 3 hours at 95°C. 0.1% sodium azide was added and the mixture was stored at room temperature for approximately one year. Then gels were subjected to drying by evaporation till the water content was reduced to 13.5% . Dried starches with less than 1% water content was obtained by granular drying.

The below figure 1(a) shows the mashed potatoes

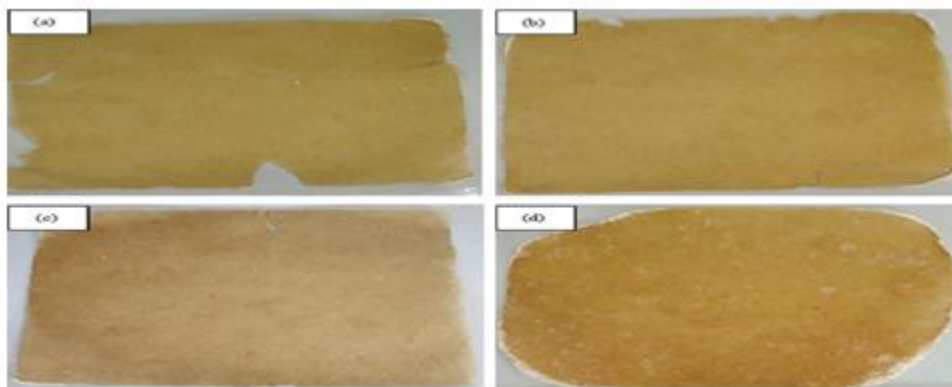
**Figure 1 (a)**  
**Mashed potatoes for starch extraction**



The below figure 1(b) shows the dried potato starch

**Figure 1 (b)**

**The dry granular potato starch is obtained**

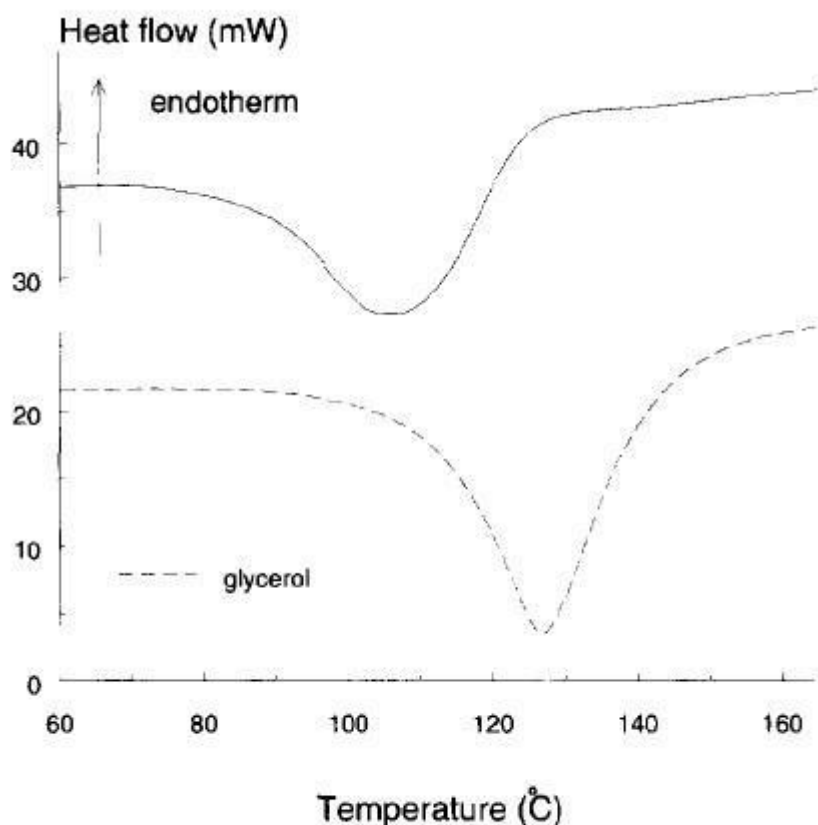


**(B) The melting of dry granular potato starch**

Dry starch has been melted with an excess of glycerol. The thermograms are shown in

figure 2. Exothermic transitions are observed with an onset temperature of 75°C and

100°C respectively for glycerol.

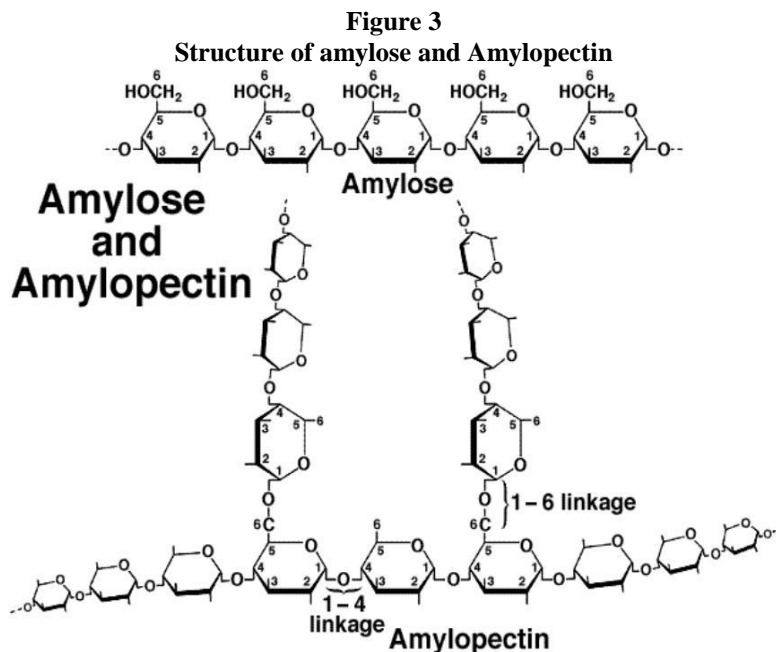
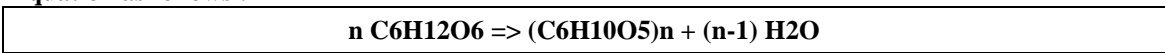


**Fig .2 The thermograms of the heating of dry potato starch with glycerol**

**Figure 2**

The above figure represents the thermograms of the heating of dry potato starch with glycerol

Equation as follows :



The above image represents the structures of amylose and amylopectine. Here the branching of amylopectine are visible.

There are two products which can produce amylopectin and amylose.

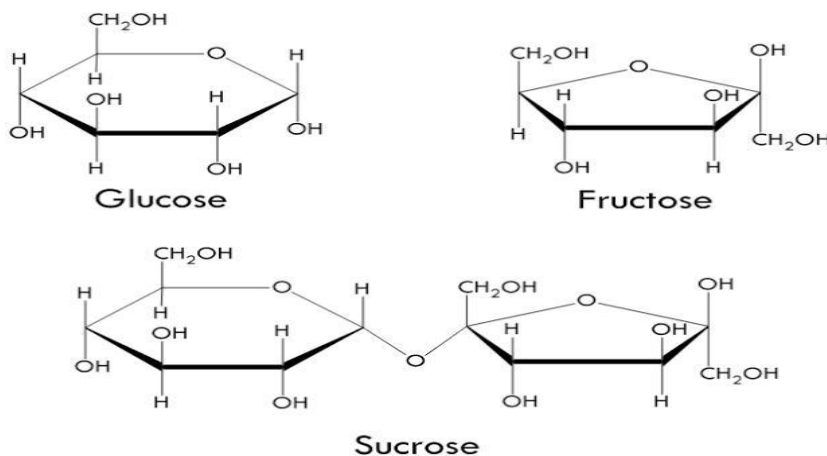
For amylopectin „n“ in the above equation can vary between 2,000 and 2,00, 000, which means that the amylopectin chains are formed by between 2,000 and 2,00, 000 glucose units, which form branching every 24 to 30 glucose units.

For amylose, „n“ varies between 300 and 3,000 and there are no branching in the chain ,in contrary to amylopectine, and, as a consequence, amylose is less soluble in water than amylopectine because its molecules do not link to water molecules via hydrogen bonds.

The below image represents the corn syrup structure

**Structure of corn syrup**

**Figure 4**



**(C) Addition of Corn syrup :**

Corn syrup is commercially available in super markets .The potato starch used contains 70 % amylopectin and 30% amylose. Corn syrup contains varying amount of maltose and higher oligosaccharides.Sugars such as Glucose, Fructose, Sucrose are present. Addition of Corn syrup makes the bio-plastic more flexible.

**(D) Addition Of Water to starch :**

Water plays an important role in the production of bio-plastic. Initially, it acts as a solvent to dissolve the starch. Secondly, it helps the starch molecules to stay disrupted after heating.

The below table shows the gelatinization and melting parameters of potato starch with water content.

**Table 1**

**Table 1**  
Effect of water on the gelatinization and melting parameters of potato starches differing in water content

Water <sup>a</sup> (%)	$\Delta H$ (J/g starch)	$T_o$ (°C)	$T_p$ (°C)	$T_c$ (°C)	$\Delta T$ ( $T_c - T_o$ )
17	0.5	105	148	170	65
18	1.5	105	125	160	55
24	2.5	100	135	160	60
31	8	80	97	108	28
41	17	60	90	97	37
49	15	64	80	104	40
56	16	57	62	81	24
66	16	57	63	75	18
87	16	57	64	70	13

<sup>a</sup> On the basis of total mass.

**(E) Addition Of Acid (Vinegar):**

6% Vinegar in volume solution of acetic acid liberates acetate ions and hydrogen-ions in solution. This is important, because ions react with the starch polymers and make them disordered more easily in the solution. This disorder, results from the disruption by the water and the ionization by the acetic acid, makes the resulting cast film more homogenous.

**(F) Determination of glycerol-water/starch ratio:**

Some preliminary tests are performed to find out the accurate proportion of mixing glycerol and water with starch where our yield (plastic) is a confirmation to our criteria. The yielded plastic has to be flexible, but not too soft.

**Figure 5**



**Glass beaker with the mixture of glycerol-water/starch**

**Table 2**

**Table 2**  
Effect of glycerol content on the gelatinization and melting parameters of potato starch at different water–starch ratios

Starch–water ratio	Water <sup>a</sup> (%)	Starch <sup>a</sup> (%)	Glycerol <sup>a</sup> (%)	$\Delta H$ (J/g starch)	$T_o$ (°C)	$T_p$ (°C)	$T_c$ (°C)	$\Delta T$ ( $T_c - T_o$ )
5-1	17	83	0	0.5	105	148	170	65
	13	67	20	1	103	145	170	67
	13	63	24	0.6	100	140	170	70
	11	51	36	1.3	102	108	160	58
	10	50	40	13	103	108	150	47
	9	42	49	14	104	109	140	36
	8	40	52	15	104	110	138	34
	4	20	76	20	105	111	135	30
	3	16	81	19	104	110	133	29
3-1	24	76	0	2.5	85	145	160	75
	19	60	21	5	100	135	160	60
	14	46	40	11	103	108	150	47
	9	30	61	18	106	111	130	24
1-1	6	19	75	17	109	113	124	15
	49	51	0	16	60	71	104	40
	42	43	15	17	71	80	105	34
	35	36	29	18	80	84	108	28
	23	23	54	15	99	106	115	16
	13	13	74	16	117	122	134	17

<sup>a</sup> On the basis of total mass.

The below table shows the determination of glycerol-water / starch ratio

The below table shows the mass of starch production in the three solutions ( vinegar, corn syrup, glycerol )

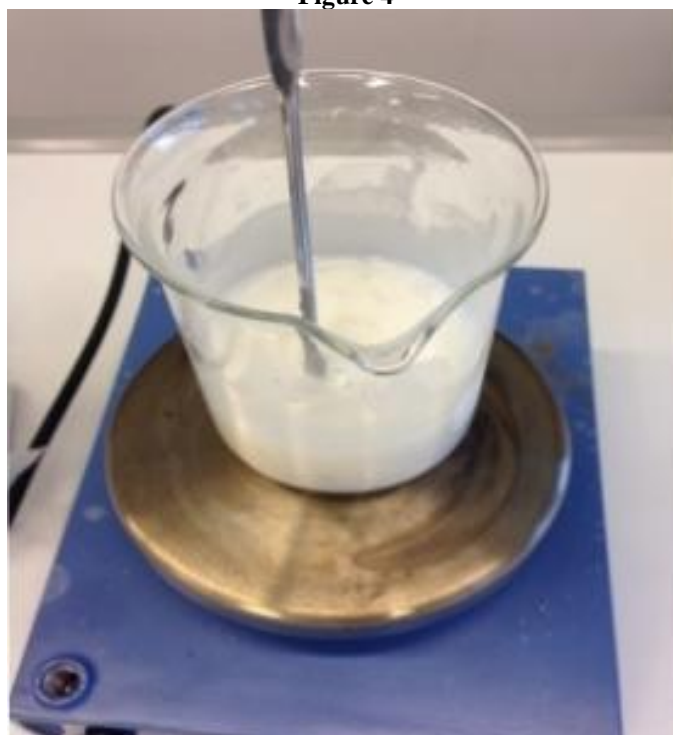
**Table 3**

Solution number	Mass of water %	Mass of starch %
1 (vinegar)	84	17
2 ( corn syrup )	57	40
3 (glycerol )	60	47

Plastics produced with solution 2 ( corn syrup) resulted the best to the conditions which led to further continuation of this proportion for further research purpose.

The below figure shows determination of gelatin mass by heat test

Figure 4



Determination of the amount of acetic acid

**(G)Determination of the amount of acetic acid :**

The starch solution was subjected to heat to determine the temperature of gelatin.

After 3tests ( heat test, strength test and degradability test) it was concluded that the processing of gelatin begins at a temperature of 50 degrees centigrade. 3 tests ( heat test, strength test and degradability test) were performed to rule out the required amount of vinegar to make the plastic homogenous.

Table 4

Homogeneity experiment number	Amount of acetic acid in % of total mass
1 ( heat test )	6
2 ( strength test )	9
3 ( degradability test )	7.6

**(H)Determination of the amount of corn syrup :**

3 test ( heat test , strength and degradability test ) were performed again to rule out the required amount of corn syrup to make the plastic flexible.

Table 5

Flexibility experiment number	Amount of corn syrup in % of total mass
1 ( heat test )	16
2 ( strength test )	10
3 ( degradability test )	5.7

#### IV. Discussion

The yield ( plastic ) was subjected to drying and then removed from the mold and examined for its characteristics . The product is exposed to high temperature. It is found that at high temperature exposure is satisfactory and the material becomes charred. The thickness and firmness of the product are observed and appreciable. The product also has elasticity such that the experiment conditions can be modified to synthesize thin firm for the application in manufacturing of raincoats, bags and packaging materials.

Food color can be added during the synthesis to get colored products. The product made out of potato starch and lab starch are compared. The elasticity is found to be much better in potato starch made plastic whereas it is very low for lab starch plastic. Also, the firmness and tensile strength is found to be much higher for potato starch. The addition of corn syrup during the synthesis may improve the plasticity of potato starch plastic. With this experimental conditions, potato starch is a better choice than lab starch for plastics. vinegar is being used as a food preservative, where the synthesized product can be subjected to clinical trial for edible purpose since corn syrup is also used as one of the raw material.

The below image represents the final yield ( Bio-Degradable Plastic)

**Figure 5**

**The final yield of bio-degradable plastic**



#### V. Conclusion :

The bio-plastic is been synthesized from potato starch which is a natural source. Instead of using packaging material made from synthetic polymer, new material developed from potato starch can be substituted so that it can be fermented. For disposal purposes it will be easy and economical one. The bio-plastic is also made out of lab starch. On comparison of both the materials made from different starch materials, the material from potato starch seems to be a very good alternative to non-degradable polymer than the one made from lab starch. The poly lactic acid (PLA) content of the synthesized material should be found out and depending on it, it can be utilized for specific application like films and bottles. The manufacturing of bio- plastics is definitely an additional advantage of renewable resource for the synthesis and there is no oil based component or trees to be cut off.

#### References :

- [1]. Bioplastics and food packaging . Nafisa Jabeen.et al. Cogent Food & Agriculture. Vol (1) , 2015 - Issue 1
- [2]. Handbook of Bioplastics and Biocomposites , Engineering Applications,Edited by Srikanth Pilla, Wisconsin Institute Of Discovery, University Of Wisconsin-Madison,USA. Copyright 2011 by Scrivener Publishing LLC. All Rights Reserved. **Library of Congress Cataloging-in-Publication Data:** ISBN 978 0-470-62607-8
- [3]. Aberle T, Burchard W, Vorwerk W, Radosta S (1994) Conformational contributions of amylose and amylopectin to the structural properties of starches from various sources. *Starch* 46, 329-335
- [4]. Brandrup J, Immergut EH, Grulke E (1999) Permeability and diffusion data. In: *Polymer Handbook 2* (4<sup>th</sup> Edn, Vol I), Wiley, NY, pp 543-569
- [5]. Delville J, Joly C, Dole P, Bliard C (2002) Solid state photocrosslinked starch- based films: A new family of homogeneous modified starches. *Carbohydr- rate Polymers* 49, 71-81
- [6]. Álvarez-Chávez, C. R., Edwards, S., Moure-Eraso, R., & Geiser, K. (2012). Sustainability of bio-based plastics: general comparative analysis and recommendations for improvement. *Journal of Cleaner Production*, 23(1), 47–56.
- [7]. Babu, R. P., O'Connor, K., & Seeram, R. (2013). Current progress on bio-based polymers and their future trends. *Progress in Biomaterials*, 2(1), 8.
- [8]. Gironi, F., & Piemonte, V. (2011). Bioplastics and Petroleum-based Plastics: Strengths and Weaknesses. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 33(21), 1949–1959.
- [9]. European Bioplastics. (2014). *Bioplastics facts and figures* (pp. 1–6).
- [10]. Khoo, H. H., & Tan, R. B. H. (2010). Environmental impacts of conventional plastic and bio-based carrier bags. *The International Journal of Life Cycle Assessment*, 15(4), 338–345.



- [11]. Bioplastics made from upcycled food waste. Cecilia Cecchini \_Prospects for their use in the field of design. The Design Journal. Vol (20), 2017 – issue sup 1
- [12]. A Review on Biodegradable Plastics . T. M. Aminabhavi et al. Polymer-Plastics Technology and Engineering. Vol (29), 1990 – Issue 3
- [13]. Bioplastics and Petroleum-based Plastics: Strengths and Weaknesses . F. Gironi et al. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects Vol (33) , 2011 - Issue 21
- [14]. Biodegradable Plastics Based on Cellulose Acetate . Alexander Ach. Journal of Macromolecular Science, Part A Volume 30, 1993 - Issue 9-10
- [15]. Biodegradable Plastics from Renewable Resources . A. Demibras . Energy Sources, Part A: Recovery, Utilization, and Environmental Effects . Volume 29, 2007 - Issue 5
- [16]. Innovation and Industrial Trends in Bioplastics . Antonio U. B. Queiroz .et al. Polymer Reviews
- [17]. Volume 49, 2009 - Issue 2
- [18]. (17)Synthesis of Poly(Lactic Acid) . Rajeev Mehta . et al. Journal of Macromolecular Science, Part C: Polymer Reviews . Volume 45, 2005 - Issue 4
- [19]. (18)Bio products from potatoes. Vivita priedniece 1 Kriss Spalyins Ivanovs 1 and Dagnija Blumberga 1 Institute of energy systems and environment , Riga Technical University , LV – 1048, Riga, Latvia. Volume 21 , Issue 1
- [20]. (19)Development of highly-transparent protein/starch-based bioplastics. J. Gonzalez-GutierrezP.PartalM.Garcia-MoralesC.Gallegos. Volume 101 Issue 6
- [21]. (20) Application of bioplastics for food packaging. Trends in Food Science & Technology. Volume 32, Issue 2, August 2013, Pages 128-141

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