Sarva Bio Remed, LLC
310 Emig Road,
Emigsville, PA 17318
Phone: 717-779-0040
Fax: 419-710-5831

Bioremediation of Polystyrene

1. Biodegradation of expanded polystyrene (EPS) packaging peanuts (Bench scale)

Expanded polystyrene packing material popularly known as "peanuts" was added to sterile water (control without bacteria) and in 10% AgroRemed (SBR product) solution and the flasks were shaken on a reciprocal shaker at 180 rpm. It was observed that the peanuts disintegrated in both the conditions in 24 hours. However, suspended particles were observed in the Control samples but there were no visible particles of peanuts were observed in the test sample as seen below.

The material in the flasks was sent to a laboratory to test for bacterial population and also release of any BTEX compounds in the medium. The results listed in Table below showed that during bioremediation of the polystyrene peanuts by the bacteria, there was an appreciable reduction of the values of BTEX indicating that bioremediation of "peanuts" not only remediated the synthetic polymer material but also reduced the BTEX levels in water. It allowed a safe discharge levels for water after treatment. High population of bacteria in the sample indicated that the bacteria in our products were consuming the EPS material as food. This suggested that Expanded polystyrene (EPS) material that formed the basis of peanuts were being biodegraded through bacterial activity. The study was terminated when uniform dissolution of peanut material was noticed.

Sarva Bio Remed, LLC
310 Emig Road,
Emigsville, PA 17318
Phone: 717-779-0040
Fax: 419-710-5831

Table 1: Microbiological and chemical analyses of "peanuts" in control and in 10% Biodispersion Product

Date	Parameter	Value in 10% Biodispersion Product	Value in control
10/11/2010	Heterotrophic plate count	790,000,000 (7.9 X 10 ^ 8)	NM (not measured)
10/11/2010	Total suspended solids in parts per million	140 ppm	210 ppm
10/11/2010	Benzene (in parts per billion)	< 5 ppb	< 20 ppb
10/11/2010	Toulene	< 5 ppb	< 20 ppb
10/11/2010	EthylBenzene	< 5 ppb	< 20 ppb
10/11/2010	m+p-Xylene	< 5 ppb	< 20 ppb
10/11/2010	o-Xylene	< 5 ppb	< 20 ppb
10/11/2010	Total Xylene	< 5 ppb	< 20 ppb

Industrial bioremediation of polystyrene peanuts

These results were encouraging and the testing of polystyrene packaging material was further extended to a prototype 50 gallon batch in a fermenter using store-bought peanuts in 10% Biodispersion Product. The results showed that expanded polystyrene peanut material mixed uniformly in the tank and there was no visible particulate material after 20 days. The solution remained very turbid indicating active bacterial growth utilizing Expanded Polystyrene as the sole source of food. These packaging peanuts were prepared with biodegradable EPS and the results show that the EPS packaging material can be safely biodegraded by bacteria in a short period and thus reduce the impact of waste peanuts in environment. In the landfill degradation of EPS is believed to take many years and more often than not the material became a litter.

Example 6: Expanded polystyrene Cups: Bench scale evaluation

Expanded Polystyrene foam cups cuts in 6 cm x 2 cm strips and were put in flask one containing 10% Biodispersion Product with a sterile control and were shaken at 180 rpm along with other test material. Expanded polystyrene cups exhibited strong static nature and remained floating on water or remained attached to the sides of the wall. In 48 hours the strips in 10% Biodispersion Product showed that the material slowly adsorbed water and there was a light yellow tinge around the edges of the strip and the medium showed heavy turbidity. This indicated that the material of polystyrene cups was undergoing some transformation. The bench scale studies confirmed that the material was biodegradable.

Sarva Bio Remed, LLC
310 Emig Road,
Emigsville, PA 17318
Phone: 717-779-0040
Fax: 419-710-5831

Industrial fermentation of Expanded Polystyrene cups

A prototype bulk study was conducted to examine the biodegradation of extended polystyrene cups in fermenter using 10% Biodispersion Product as the source of bacteria for achieving the bioremediation. In 80 gallon fermentation tanks 50 gallons of water and 5 gallons of Biodispersion Product was added followed by the addition of 20 large size cups purchased from a local grocery store. These cups were broken into small size about 7 cm square pieces. The contents of the tank were mixed using industrial mixers continuously for providing air to the bacterial population. The contents were maintained at room temperature. The extended polystyrene pieces were so light that they would not remain in water and a large number remained attached to the wall and even after scraping the sides, next day almost same number of pieces were attached on to the wall. The size of these pieces was reduced almost by half but many pieces of extended polystyrene still remained on the side. After 7 days the pieces became less than 5 millimeters.

In the industrial study it is seen that the bacteria were acting on the Expanded Polystyrene (EPS) cup material just as they acted on the 'peanuts" packing material in the earlier study. The bacterial population was found to be 4.3 billion/ml. The study was continued for three months without adding any additional nutrients or salts and the continued bacterial growth recorded was considered to be due to the release of nutrients by the polymer degradation during possible de-polymerization. The material was periodically analyzed for bacterial population density. At the end of 2 months the plastic material was completely disintegrated into smaller particles. The material was sent for determination of Molecular weight using Gel permeation Chromatography (GPC) of the material during bioremediation. Three different samples were analyzed namely, the control new cup, the surface layer after centrifugation of fermented medium and insoluble material in the centrifuged sample. The Expanded Polystyrene cup had an average molecular weight of 449,465 whereas the top layer of liquid after centrifugation showed the molecular weight of the dissolved fraction to be 3,162. The molecular weight of insoluble fraction of the material in the medium was 365,956. The analysis indicated that the degradation of the polymer was through the breakage of the molecular structure of the EPS material.

It was not possible to draw any positive conclusions from this data. It was also not possible to determine the nature of breakdown products.

Sarva Bio Remed, LLC
310 Emig Road,
Emigsville, PA 17318
Phone: 717-779-0040
Fax: 419-710-5831

Figure 2. Condition of EPS after 4 hours.

Fig 3. Condition after 48 hours

Fig. 4. After 8 days

Fig. 5. After 30 days

Fig. 6 & 7. Insoluble material remaining after 30 days

The above photographs show a steady transformation of the EPS material from being hydrophobic at the start of the fermentation to a strong hydrophilic material within 48 hours and material adhering to the tank walls was less and the size of the material was reduced considerably. The objective of the study was to develop a zero discharge process.