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# ENVIRONMENTAL ASSESSMENT FOR BAREX®210 RESIN BOTTLES

## FOOD ADDITIVE PETITION: NO. 8B4564

**Prepared for:**
**BP CHEMICALS INC.**
**4440 Warrensville Center Road**
**Cleveland, OH 44128-2837**

**October 14, 1999**

003145

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2. **DATE:** Oct 15, 1999 (Originally submitted September 30, 1997, Revised March 30, 1999, July 22, 1999 and Oct 15,1999)

3. **NAME OF PETITIONER:** BP Chemicals Inc.

4. **ADDRESS:** 4440 Warrensville Center Road
Cleveland, OH 44128-22837

5. **DESCRIPTION OF PROPOSED ACTION:**

(a) **Requested Approval:**

Barex®210 Resins, identical to the subject of this petition, are approved for several food contact applications (177.1480). They are utilized as formed sheet and films, but not beverage containers, and are marketed under the trade name Barex®210 Resins. The largest application for Barex®210 Resins is extruded sheet for food packaging (especially luncheon meats). The present application requests approval for the use of the same acrylonitrile-methyl acrylate-butadiene-copolymer to fabricate beverage containers. The petition requests approval of these beverage containers for fruit and vegetable juices and drinks, and teas.

(b) **Need for Action:**

The application contemplated by this petition would open a modest sized new market for Barex®210 Resins. Of the 50 percent of the juice and drink market which is aseptically or cold filled, 85 percent is packaged in paperboard 'bricks' or 'gable top' paper containers. Because of the low permeability of the Barex®210 container to gases, it has the advantage of maintaining the freshness of juices for longer periods than other plastic containers. A portion of the marketers who value both transparency and a superior oxygen barrier for their premium products provide a potential niche for the more expensive Barex®210 Resins. Realistically, we anticipate no more than 10 million pounds per year of new demand for Barex®210 Resins due to our entry into the United States fruit and vegetable juices and drinks, and teas markets.

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**(c) Locations of Use:**

The nitrile rubber modified acrylonitrile methyl acrylate copolymer, trade marked as Barex®210, will be incorporated into containers at production plants located throughout the United States. Containers fabricated from the copolymers are expected to be used by consumers primarily in the home but also in other food distribution sites, e.g., restaurants, at sports events, and other places where consumers ingest beverages.

**(d) Locations of Disposal:**

Disposal of food-packaging materials that are subject to the proposed action is expected to occur nationwide with the materials ultimately being deposited in municipal solid waste landfills or incinerated.

## 6. IDENTIFICATION OF CHEMICAL SUBSTANCES THAT ARE SUBJECT OF THE PROPOSED ACTION:

**(a) Complete Nomenclature:**

The principle constituent of Barex®210 Resin is (acrylonitrile/methyl acrylate)-g-(butadiene/acrylonitrile) copolymer.

**(b) Chemical Abstracts Service (CAS):**

CAS Number: 27012-62-0

**(c) Molecular Weight:**

The basic resin polymer is a complex mixture of long polymer chains, some linear, some cross-linked and some branched. Most of the material is heavily grafted and cross-linked and has a weight average molecular weight greater than 1,000,000 atomic units. The mean chain size of ungrafted chains is 100,000 atomic units

**(d) Molecular Formula:**

The approximate empirical formula is $C_8H_{10.3}ON_{1.7}$. Because the exact empirical formula is subject to conditions of manufacture including temperature and pressure, the empirical formula given is a best estimate.

**(e) Structural (Graphic) Formula:**

The basic resin is composed of polymerized units of acrylonitrile, methyl acrylate and 1-3-butadiene containing the following units in many different combinations with one another: -(CH2CNCH-)-, -(CH2CHCO2CH3-)-, -(CH2CH=CHCH2-)- and –(CH2CH2-CH=CH)-

**(f) Physical Description:**

Barex®210 bottles typical of those proposed for juices, drinks and teas are depicted in Brochure No. BX-101. Barex®210 bottles will be fabricated from extrusion grade resin. This descriptive brochure is attached to this EA, (Attachment 1).

## 7. INTRODUCTION OF SUBSTANCES INTO THE ENVIRONMENT:

**(a) Manufacture:**

There are no extraordinary circumstances involved in the manufacture of Barex®210 Resin. The manufacturing process for Barex®210 Resin conforms to all general and specific emission requirements (including occupational) promulgated by Federal, State or local environmental agencies. The additional production of Barex®210 Resin contemplated in the proposed petition will conform fully to these same requirements. The additional production of Barex®210 Resin will not threaten a violation of Federal, State, or local environmental laws nor will it adversely affect a critical habitat of any endangered species.

**(b) Use:**

Little or no introduction into the environment of the copolymer subject to this section will result from its use because the copolymer is almost completely incorporated into food-packaging materials and essentially all of the copolymer is expected to remain with food packaging throughout the use of the polymer.

**(c) Disposal:**

Based on migration studies, which were performed to demonstrate the safety of the copolymer subject to this action and reported elsewhere in this Food Additive Petition, only very low levels of substances are expected to leach from articles fabricated with the copolymer after disposal to landfills. The copolymer subject to this petition is composed of carbon, hydrogen, oxygen, and nitrogen. Adding the copolymer to waste that is burnt will not alter significantly the emission from municipal waste incinerators. The market volume of the copolymer is a very small fraction of the municipal solid waste generated and disposed of in any single combustion site or in the United States as a whole. See Table 1.

## 8. FATE OF EMITTED SUBSTANCES IN THE ENVIRONMENT:

No information need be provided of the fate of substances released into the environment as a result of use and disposal of the subject copolymer, because as discussed under item 7, only small quantities, if any, of substances will be introduced into the environment.

## 9. ENVIRONMENTAL EFFECTS OF RELEASED SUBSTANCES:

No information need be provided on the environmental effects of substances released into the environment as a result of use and disposal of the subject copolymer, because as discussed under Item 7, only small quantities, if any, of substances will be introduced into the environment. Therefore, the use and disposal of the copolymer is not expected to threaten a violation of applicable laws and regulations, e.g., the environmental Protection Agency's regulations in 40 CFR part 60 that pertain to municipal solid waste combustors and part 258 that pertain to landfills.

### 10. USE OF RESOURCES AND ENERGY:

**(a) Basic Information:**

(1) Market volume: The anticipated maximum market volume for the proposed use subject to FDA regulation is or of Barex®210 resin.

Given the limited production capacity for Barex®210 Resins, as well as other constraints mentioned below, penetration of the United States markets for fruit and vegetable juices and drinks, and teas by Barex®210 Resin bottles is anticipated to be minimal by commodity packaging standards.

The proposed market for Barex®210 containers is also limited by the restricted nature of the proposed food applications, i.e., – teas and fruit and vegetable juices and drinks. According to U.S. Department of Agriculture (USDA) data, annual per capita consumption is 8.6 gallons for juices, 5.7 gallons for drinks, and 7.0 gallons for teas. According to U.S. Census estimates as of July 1, 1995, the population of the United States was 262,755,000 individuals. If we combine the per capita figures for juices and drinks, and multiply by the approximate U.S. population, we obtain a total market size of 3.76 billion gallons per year. Performing the same calculation for teas we obtain a total market size of 1.84 billion gallons per year.

A realistic estimate for bottle size and weight would be an average size of one liter and an average weight of 40.3 grams per bottle. With Barex®210 Resin production of , bottle production could be million bottles, if we make the extremely conservative assumption that all added Barex®210 Resin production will go into the United States juice and drink market. If these bottles held one liter each, million bottles would contain . Dividing by the annual market for juices, drinks and teas of 5.6 billion gallons would give a market share of only percent.

The market share available to Barex®210 Resins is considerably smaller for the following reasons: There are physical limitations on the use of Barex®210 Resins in these markets. Due to the inherent thermal properties of the resin (low Tg), bottles blown from Barex®210 Resins cannot be hot-filled. Half of containers for juices, drinks, and teas bottled in the United States are hot-filled. The other half of the market is aseptically filled or cold filled. (Attachment 2: Miyares Packaging Management Report Summarizing Fill Types).

Consumer application patterns also limit the market potential for Barex®210 Resin bottles. In the juice market, based on data obtained from MRCA, about 27 percent of the consumption is from frozen concentrate. If the product is frozen, the outstanding oxygen barrier provided by Barex®210 Resins is not required. In the drinks market, 53 percent of the consumption is home prepared from dry powder which would also eliminate the requirement for Barex®210 Resins. In the tea market, only 2 percent of the total consumption is canned or bottled, the majority being home prepared from hot water and tea bags. (Attachment 3: MRCA's Report of Consumption Patterns.)

Finally, there are economic limitations to the market potential for Barex®210 Resin bottles. juices, drinks, and teas are currently packaged in a variety of materials including glass, paperboard, aluminum, and plastics. The choice of material is based on a variety of factors including cost. Barex®210 Resins are high-cost materials and they would be selected only for premium quality applications in which package transparency and a superior oxygen barrier is required. Of the 50 percent of the juice and drink market which is aseptically or cold filled, 85 percent is packaged in paperboard "bricks" or "gable top" paper cartons. If marketers of these products do not value package transparency, they will not select the more expensive Barex®210 Resins for their products. Even where transparency is desired, other plastics provide a less expensive package, unless a superior oxygen barrier is needed. Consequently, only premium quality niche products make sense for Barex®210 Resins. These premium quality market niches are small by industry standards but are extremely attractive to the Barex®210 Resin business. Applications of only several million pounds of resin per year would constitute significant growth opportunities. Realistically, we anticipate no more than per year of demand for Barex®210 Resins due to our entry into the United States juice, drink, and tea markets. Nevertheless, this opportunity is critical for the growth of the Barex®210 Resins business.

(2) Types of food contact articles and food applications: Food containers intended for teas and fruit and vegetable juices or drinks are the object of the requested approval. These containers will consist of blow-molded bottles or other rigid or semi-rigid containers. The capacity of the containers will eventually reflect the market demand for different sizes. Based on our experience in Europe, where the Barex®210 bottles are in use for the requested applications, we anticipate that two sizes, a one-liter and a half-liter size, will be the most common. One-liter bottles weigh approximately 40.3 grams with label; ½ liter bottles weigh approximately 25 grams. (The bottles tested in the migration studies, were a slightly different shape and slightly heavier, 57.4 grams vs. 40.3 grams. Most of the excess weight was in the neck and bottoms. The surface area and the wall thickness were comparable.)

(3) Competitive food packing materials: The proposed use of Barex®210 bottles is anticipated to compete with and to some extent replace the current packing types used for teas and fruit and vegetable juices or drinks. As indicated above, juices, drinks, and teas are currently packaged in a variety of materials including glass, paperboard, aluminum, and plastics. Our marketing experience in Europe leads us to expect that a market niche exists for those consumers desiring premium quality products. Marketers must value both package transparency and a superior oxygen barrier before they will pay the extra cost for our product. This limits the size of our eventual market penetration to premium quality fraction of the entire fruit and vegetable juices or drinks market.

To the best of our knowledge acrylonitrile/styrene copolymer containers do not presently serve this niche market. While FDA approval exists for acrylonitrile/styrene copolymer containers, we are not aware that these containers are currently used for our anticipated food uses. There is no operating plant where they are produced. The original ANS bottles were extremely brittle and found little consumer acceptance. Consumers and food-packaging companies prefer glass bottles or plastic containers with other properties than those possessed by ANS copolymers. Nor are teas and fruit drinks and juices currently packaged in the United States in metal containers to any significant extent. Furthermore, plastic-coated, laminated and layered paperboard is used for the low end of the market not for premium packaging. Therefore the potential competition of Barex®210 bottles with containers made from metal or plastic-coated, laminated and layered paperboard is expected to be negligible. Unless the current demand for different packaging types changes specifically as a result of the availability of Barex®210 containers, we anticipate that transparent plastic containers and glass bottles will be the main competitors to Barex®210. We therefor expect that Barex®210 bottles will to some extent replace both glass bottles and other plastic containers in its market niche.

(4) Disposal Patterns: Beverage containers made from the subject copolymer will eventually become part of the municipal waste stream (MSW) and are either buried in land fills or incinerated in municipal or other waste disposal plants. This conclusion is based on evidence that little if any Barex®210 bottles are likely to be recycled. The EPA report, "Characterization of Municipal Solid Waste in the United States: 1997 Update" (EPA CMSW, 1998), contains recent information on disposal patterns of different waste types. Table 7, page 40 of this report shows that only 0.96 percent of the category of "other resins" are recycled. This is the category that is assigned to nitrile rubber modified acrylonitrile methyl acrylate copolymer (trade marked as Barex®210 containers).

The EPA data show that when there is no recycling of a plastic material, 76 percent is disposed of in landfills and 24 percent is incinerated.(EPA CMSW, 1998, page 2). This amounts to land disposal of Barex®210 bottles. The landfill required for of Barex®210 is 21,408 cu. yd/year. This assumes a bulk density of 355 lbs/cu.yd. for plastic containers. Approximately 0.24 x or of Barex®210 will be incinerated. See Table 2.

The reduction in bottle volumes caused by compaction in landfills will be proportional to the anticipated bulk densities for glass and Barex®210. From Table B-8 in the EPA Report mentioned above, we have taken the appropriate bulk densities for glass and Barex®210 as 2,800 and 355 lbs/cu.yd., respectively. This is a ratio of 1 to 7.9.

**(b) Potential for Impacts on Solid Waste Management Strategies and on Energy Use:**

(1) Solid Waste Management Strategies: The scenarios discussed below subsume the realistic possibilities for the distribution of Barex®210 into the subject food areas and the replacement of current packaging. We examine three possibilities: (1) that Barex®210 will replace both glass and other plastic containers approximately equally, (3) that Barex®210 will replace only glass bottles and finally, (3) that Barex®210 will replace only plastic containers. The impacts on incineration of these three scenarios may differ for several reasons.

1. A portion of glass is recycled while Barex®210 bottles are not rexpected to be recycled.
2. A portion of other plastic is recycled and Barex®210 bottles are not expected to be recycled.

3. The same volume container can be made with less Barex®210 than glass.
4. The bulk densities of glass and plastic in landfills are different.
5. The bulk densities of waste glass from incinerators and landfill compaction are different.

Similarly the impacts on landfill for these three scenarios may differ for these reasons as well as for others:

6. The energy profiles for the production, recycling, secondary packaging, filling and distribution, and solid waste disposal will differ for glass and Barex®210 bottles.
7. The energy profile also depends on the size of the bottles.

For the reasons stated above, we anticipate that plastic containers and glass bottles will be the main competitors to Barex®210 bottles. However because of the vast use of both plastic containers and glass bottles for other food uses and for non-food uses the impact of Barex®210 bottles on the waste stream will be negligible in comparison. (Attachment 4: Facts and figures of the Plastics Industry, 1996). This overriding fact, summarized in Table 1, should be borne in mind in evaluating the information below.

Generation and recovery data for glass, plastic and Barex®210 containers are given in Table1. The glass and MSW data are taken from Tables 5, 7 and ES-1 in EPA's 1998 report: "Characterization of Municipal Solid Waste in the United States: 1997 Update" U.S. EPA Municipal and Industrial Solid Waste Division, Office of Solid waste Report No. EPA530-R-98-007.

**TABLE 1**

**Approximate Generation and Discard of MSW and Glass, Plastic, and Barex®210 Containers Based on US EPA 1997 Data**

| Product Category | Generation (1000 tons) | Recovery | | Discard | |
|---|---|---|---|---|---|
| | | (1000) tons | percent | (1000) tons | percent |
| Total MSW | 210,700 | 57,300 | 27.3 | 153,400 | 72.7 |
| Glass Products | 12,400 | 3,170 | 25.7 | 9,180 | 74.3 |
| Glass Containers | 11,000 | 3,170 | 28.7 | 7,870 | 71.3 |
| Plastic Products | 19,760 | 1,060 | 5.4 | 18,700 | 94.4 |
| Plastic Containers | 2,630 | 670 | 25.5 | 1,960 | 74.5 |
| Barex®210 Containers* | | Neg. | 0.0 | | 100 |

*Based on total estimated Barex®210 production capacity of 10 million pounds.

**(A)** ***Impacts on recycling:***

*(i). Barex®210 Resin bottles versus acrylonitrile/styrene (ANS):*

Barex®210 bottles will not compete with acrylonitrile/styrene copolymer containers. While acrylonitrile/styrene (ANS) bottles are approved, to our knowledge they are not commercially available today. (See Section 10(a)(3) *Competitive food packaging materials.*) Barex®210 Resin is already on the market in the form of extruded sheets for food packaging. Both Barex®210 Resin and ANS are classified in the same recycling category–recycle code 7. There is currently very limited recycling of plastics classified in recycle code 7. Therefore, the action to permit use of Barex®210 Resin in beverage containers has little potential to significantly affect existing recycling programs for code 7 plastics.

*(ii). Barex®210 versus Glass*

Glass bottles are expected to be a major competitor to Barex®210 containers for the packaging of teas and fruit and vegetable drinks and juices. This use of Barex®210, currently a nonrecycled material, will in part replace glass, a recycled material. According to the Chemical Economics Handbook published by SRI International, there were 41.5 billion glass containers produced in the U.S. in 1994. According to data published by the Corning Museum of Glass, 37 percent of glass bottles and jars are recycled. This places the number of glass containers recycled in the U.S. at approximately 15.3 billion per year. As noted in the Use Section, per year of Barex®210 Resin sold into the subject markets would constitute the upper end of the estimate range. would make about million bottles (1 liter). This would represent less than 1 percent of recycled glass containers. Therefore it is not anticipated that the introduction of Barex®210 Resin bottles would have a harmful effect on the overall success of U.S. glass recycling.

*(iii). Barex®210 Resin bottles versus other transparent plastic bottles*

Transparent plastic bottles such as polyethylene terephthalate (PET), high-density polyethylene (HDPE), and polypropylene (PP) constitute potential competitors to Barex®210 bottles. These competitive bottles are recycled. A potential concern is that discarded Barex®210bottles could intermingle with these materials rendering them unrecyclable.

This potential concern is mitigated in the case of Barex®210 Resin because the Barex®210 bottles are easily recognized and can easily be removed from the waste stream. In effect then Barex®210 bottles are not "look alike" bottles. Barex®210 Resin bottles are more yellow and hazier than competing bottle resins, especially PET. Haze of a 125 mil injection molded plaque of Barex®210 Resin ranges from 7 to 15 percent, while the haze of similar pieces molded from PET is ~1 percent. The minimum yellowness of 125 mil thick sheet of Barex®210 Resin is 23; an analogous sample from PET would be <5. While the yellow color can be masked with blue tint, the result is an even hazier bottle. The "blue tint" is a mixture of two approved dyes: FDA Blue #2 and FDA Red # 40; both are Aluminum lakes. Barex®210 Resin bottles can easily be distinguished from other bottle resins spectroscopically. It is one of a very few packaging plastics derived from acrylonitrile; these plastics absorb infrared light in the nitrile region of the IR spectrum, a portion transmitted through other resins. These characteristics are sufficiently distinctive and either singly or combined allow easy recognition and separation of Barex®210 bottles from the waste stream.

There is also a process that is being used commercially in Europe to identify Barex®210 bottles in the waste stream. MSS (Nashville, TN), the leading supplier of automated plastic container separation machinery, has available a sensor to distinguish and remove Barex®210 Resin bottles from a recycle PET stream. This sensor utilizes near-infrared (NIR) transmission spectroscopy to identify Barex®210 or PET resins. Barex®210 bottles are ejected from the PET stream by air nozzles. At Barex®210 bottles levels of 10 percent, the sensor accurately removed all Barex®210 bottles from the stream. This technology is commercially available today on machines capable of sorting 5000 pounds of plastic bottles per hour.

Barex®210 Resin bottles can also be separated from PET, PVC, and polyolefins via common floatation technology. The density of Barex®210 Resin is 1.15 g/cc$^3$, versus 1.35 for PET, 1.36 for PVC and <1 for polyolefins. The polyolefins float on water, while the others sink. Barex®210 Resin bottles can be made to float by employing a 20 percent sodium chloride salt solution as the floatation medium. Barex®210 Resin bottles float on this solution, while PET and PVC sink. Similar technology is, or was, used to separate PE base from PET soda bottles when they were two piece units.

To support our written description of the distinctiveness of the optical character of Barex®210, we are submitting, with this EA, a sample of a Barex®210 bottle that conforms to our specifications and proposed uses, (Attachment 5).

### *(B) Impacts on landfill:*

Because the proposed food additive will have a relatively small market volume it cannot add significantly to the amount of landfill space required. As shown in Table 1, Barex®210 bottles will be at most 5/18,700 = 0.027% of the plastic waste stream and only 5/153,430 = 0.003 % of the total MSW waste stream. This overall impact should be kept in mind as specific landfill tradeoffs for competitive containers are considered in turn below.

The impact on landfill of Barex®210 relative to glass depends upon the relative amounts of the two materials required to make a bottle of a given size. According to some data provided by FDA, a liter glass bottle made from the new lighter-weight glass can be expected to weigh approximately 3 times more than a Barex®210 bottle. (V. R. Sellers, Comparative Energy and Environmental Impacts for Soft Drink Delivery Systems, National Association for Plastic container Recycling, Franklin Associates, Prairie Village, KS, March 1989, Tables 3-3 and 3-4). However according to other FDA data, a typical polymeric bottle (e.g PET), weighs just one eighth as much as a comparable glass bottle. Our own survey of currently used iced tea, and juice containers found an 8-10 fold difference in weight between glass and polymeric containers of a liter and ½ liter size. Accordingly, in the calculations below we use factors of both 3 and 8 to gauge the impact on landfill.

*(i) Barex®210 Resin bottles versus acrylonitrile/styrene*

As discussed under Section 10(a)(3) we believe that Barex®210 bottles will not compete with acrylonitrile/styrene copolymers for the proposed food container market. While acrylonitrile/styrene are approved for use in beverage containers, we are not aware of any present market applications in our requested food product area. Consumers and food packaging companies prefer glass bottles or plastic containers with other properties than those possessed by acrylonitrile/styrene copolymers.

*(ii) Barex®210 Resin bottles versus Glass:*

The total weight of competitive glass used would be approximately 3 x 5,000 tons) or 15,000 tons. We expect that 26 percent of glass competitive with Barex®210 bottles or 15,000 tons x 0.26 = 3,900 tons will be recycled based on the same source of information. Therefore 0.74 x 15,000 tons or 11,100 tons of glass will be discarded. If on average 76 percent of this is discarded in landfill, as indicated by the EPA data, the total glass waste currently added to the waste stream is 0.76 x 11,100 tons or 8,440 tons. If Barex®210 bottles replaced this use, 8,440 tons of glass or 6,025 cu.yd. of solid waste would be removed from the waste stream. Similarly 0.24 x 11,100 tons of discarded glass or 2,660 tons will be incinerated. Due the extra compaction of fused glass (bulk density = 4,400 lbs/cu.yd, (EPA, CMSW 1998) this will give rise to 1,210 cu. yd. of landfill. The total quantity of landfill volume required for disposal of the Barex®210 bottle market equivalent of competitive glass packaging = 6,025 + 1,210 = 7,235 cu.yd. These data are Tabulated in Table 2, Scenario 1A and 1B. We use the 8-fold density ratio for glass/plastic in the B scenarios. This assumption makes a large difference, approximately 7-fold to the net landfill difference.

*(iii) Barex®210 Resin bottles versus other plastic containers*

We believe that Barex®210 bottles will compete significantly with other partially recyclable plastic containers. According to EPA data, 14.8 percent of plastic containers and packaging (exclusive of soft drink bottles and milk containers) is presently recycled (Table 7, EPA, CMSW, 1998, page 40). The remainder is disposed of either by incineration (24%) or by landfill (76%). Barex®210 is not presently recycled and it is not anticipated to be recycled appreciably in the future. In most other respects: methods of production, incineration, bottle size, compaction in the landfill, etc., Barex®210 bottles and other plastic containers are approximately the same. Barex®210 bottles differ from competitive plastic containers in only two respects: density and recyclability. The density of PET is 1.35 vs 1.15 for Barex®210. A consequently greater mass of competitive plastic (5,870 tons vs 5,000 tons) must be used to equal the bottling capacity of Barex®210. Thus the potential environmental gain from competitive plastics is offset by the greater mass of plastic used. This is shown in Table 2 under Scenario 2. The discarded amount of Barex®210 is of course trivial compared to the total plastic discard of 1,960,000 tons. (See Table 1.)

*(iv) Barex®210 and 50/50 glass/plastic replacement:*

The last six rows in Table 2 (Scenario 3A and 3B) give the results of the landfill calculations if it is assumed that half the market share anticipated for Barex®210 bottles comes from glass containers and half from other plastic containers. It is clear that the more Barex®210 Resin replaces other plastic, with which it shares more similarity, the lessor the impact on landfill becomes. Using the 8-fold density ratio, a 50/50 glass/plastic replacement produces very little net change in landfill requirements - only 1,006 cu.yd. But regardless of the replacement scenarios, the impact on the waste stream is very minor because the market volume for Barex®210 bottles is small in commodity terms.

<u>Sample Calculations:</u>

Since only 74 percent of glass remains unrecycled and 24 percent 0f this is incinerated and 76 percent goes into landfill we have:

↗incinerated = 2,660 tons
(0.24)
Glass discard = 5,000 tons x 3 x 0.74 = 11,100 tons ----
(0.76)
↘landfill = 8,400 tons

------------------------------------------------------------------------------------------

Since there is no recycling of Barex®210, we have:

↗incinerated =1,200 tons
(0.24)
Barex discard = 5,000 tons --------
(0.76)
↘landfill = 3,800 tons

## Table 2

### Estimated Landfill Required For Barex®210 Bottles and Competitive Containers

| Mat. | Generated (Tons) | Recycled (Tons) | Material Discarded: Incinerated (Tons) | Material Discarded: Landfill (Tons) | Landfill (cu. Yd.): Recovered From Incin. | Landfill (cu. Yd.): Directly Added | Landfill Totals |
|---|---|---|---|---|---|---|---|
| Scenario (1A): 100% Replacement of Glass Containers (x3) | | | | | | | |
| G(x3) | 15,000 | 3,900 | 2,660 | 8,440 | 1,210 | 6,025 | (-) 7,230 |
| B | | 0 | | | 0 | 21,400 | (+) 21,400 |
| | | | | Net Change in landfill volume | | | (+) 14,400 |
| Scenario (1B): 100% Replacement of Glass Containers (x8) | | | | | | | |
| G(x8) | 40,000 | 10,400 | 7,104 | 22,496 | 3,229 | 16,068 | (-) 19,300 |
| B | | 0 | | | 0 | 21,400 | (+) 21,400 |
| | | | | Net Change in landfill volume | | | (+) 2,100 |
| Scenario (2): 100% Replacement of Plastic Containers | | | | | | | |
| P | 5,870 | 869 | 1,197 | 3,804 | 0 | 21,370 | (-) 21,370 |
| B | | 0 | | | 0 | 21,400 | (+) 21,400 |
| | | | | Net Change in landfill volume | | | Neg |
| Scenario (3A) 50/50 Glass/Plastic Container Replacement (x 3) | | | | | | | |
| G(x3) | 7,500 | 1,950 | 1,330 | 4,220 | 605 | 3,012 | (-) 3,620 |
| P | 2,935 | 435 | 598 | 1,902 | 0 | 10,685 | (-) 10,685 |
| B | | 0 | | | 0 | 21,400 | (+) 21,400 |
| | | | | Net Change in landfill volume | | | (+) 7,095 |
| Scenario (3B) 50/50 Glass/Plastic Container Replacement (x 8) | | | | | | | |
| G(x8) | 20,000 | 5,200 | 3,552 | 11,248 | 1,615 | 8,034 | (-) 9,649 |
| P | 2,935 | 435 | 598 | 1,902 | 0 | 10,685 | (-) 10,685 |
| B | | 0 | | | 0 | 21,400 | (+) 21,400 |
| | | | | Net Change in landfill volume | | | (+) 1,066 |

G = Glass, P = Plastic and B =Barex®210
Density of fused glass = 4,400 lbs/cu.yd.=2.2 tons./cu.yd.
Bulk density of compacted glass = 2,800 lbs./cu.yd. =1.4 tons.cu.yd.
Bulk density of compacted plastic or Barex®210 bottles = lbs./cu.yd. = tons./cu.yd.
Density of plastic (PET) = 1.35 g/cc; density of Barex®210 Resin = 1.15 g./cc.

(2) Impacts on Energy Use:

**(A)** ***Approach to the calculations*:**

As above, we assume complete market penetration by 10 millions pounds of Barex®210 resin and its 29.8 million-gallon capacity. (See Section 10(a)(1) *Market volume*.) Prior to the entry of Barex®210 bottles, we assume this volume of product is packed equally in unrefillable glass containers and in other transparent plastic containers, e.g., PET , HDPE and PP. (See Section 10(a)(3) *Competitive beverage containers*.)

Barex®210 bottles are not expected to be recycled and a significant fraction (estimated at 50 percent in the energy calculations) will likely replace glass, which is currently recycled. In these circumstances the energy to produce, transport, use and dispose of the subject copolymer and glass may differ. Because a PET bottle weighs only one-eighth as much as a comparable glass container and Barex®210 Resin is 1.35/1.15 times lighter than PET, we multiply the expected market volume for Barex®210 bottles by 8 x 1.35/1.15 = 9.39 to obtain the market volume of the glass that will be replaced.

The means of container production, handling and disposal of Barex®210 bottles and other transparent plastic bottles are similar. Therefore the energy profile for PET bottles (from the 1989 Franklin Associates Report) will be used as a surrogate for Barex®210 bottles. Barex®210 Resin bottles require less energy for manufacture than many other containers, from acquisition of the raw material, manufacture, through ultimate disposal of the raw material. Because of its greater strength, less raw material is required for the Barex®210 Resin bottles than for competitive plastic containers. A Barex®210 one liter bottle weighs 40.3 grams compared to 46.8 grams for a one liter PET bottle.

Additionally, the energy required to dispose of Barex®210 bottle will be slightly different from other plastics. This difference arises from recycling and occurs only for the fraction of the plastic containers that are recycled. According to Table 7 in the EPA report referred to above, (CMSW, 1998), about 14.8 percent of plastic containers in this product category is recycled. This recycling would not occur for Barex®210 containers. The energy costs of this effect would be small, given the very small impact of the Barex®210 bottle market on the total plastic waste stream. (See Table 1)

The net result of the Barex®210 bottle entry (assuming complete market penetration and 50/50 replacement of glass and other plastic containers) would be to substitute a 29.8 million gallon-capacity of Barex®210 containers equally for other plastic and glass containers. We would then have added a 29.8 million-gallon Barex®210 bottle capacity and lost 14.9 million gallons formerly packed in other plastic containers and 14.9 million gallons formerly packed in glass containers. This would add 10 million pounds of Barex®210 bottles and eliminate $10^7/2$ x 1.35/1.15 = 5.87 million pound of other plastic containers and $10^7/2$ x 1.35/1.15 x 8 = 47.0 million pounds of glass containers.

We use the "cradle–to-grave" energy values that are reported in the 1989 Franklin Associates NAPCOR Final Report for both PET and non-refillable glass containers. The pertinent Tables of the report are attached to this EA (Attachment 6). Since the anticipated market calls for 1-liter and ½ liter containers the calculations for both Barex®210 bottles and its competitors are for bottles of this size. Table 3 reproduces the pertinent data from the NAPCOR Final Report.

TABLE 3

1995 Projected Cradle-to-Grave Energy Requirements for Glass and Polymeric Bottle Systems in Million BTU (MBTU) per 1000 Gallons. Adapted from Franklin Associates 1989.

| Material | Size | Virgin Container | Recycled Container |
|---|---|---|---|
| PET | 1 liter | 22.37 | 14.95 |
| | ½ liter | 27.85 | 18.62 |
| Non-refillable Glass | `1 liter | 26.05 | 23.89 |
| | ½ liter | 26.89 | 24.94 |
| Barex®210 | 1 liter | 22.37 | N/A |
| | ½ liter | 27.85 | N/A |

***(B) Basic calculations***

To compare the energy profiles for PET, Barex®210, and glass containers we normalize the energy analysis on the basis of energy consumed per amount of food product container. Following the NAPCOR Report we use million BTU's per 1000 gallons. The most recent data refer to projections for 1995. The Tables in Attachment 6 give the energy consumed throughout the life cycle of the container, including, production, recycling, secondary packaging, filling and distribution and solid waste disposal.

The energy required for a particular beverage container in MBTU/year is given by:

$$E_{PRODUCT} = E_{AVG/CONT} \text{ x CW x MV x k, where,} \qquad \text{(equation 1)}$$

$$E_{AVG/CONT} = ( E_{RECYCLED} \text{ x } p) + (E_{VIRGIN} \text{ x } [1-p]) \qquad \text{(equation 2)}$$

Where: $E_{RECYCLED}$ = sum of energy needed for containers made from the recycled material.

| | | |
|---|---|---|
| $E_{VIRGIN}$ | = | sum of energy needed for new (virgin) containers. |
| p | = | the fraction of the market volume expected to come from recycled materials. |
| CW | = | container capacity per unit weight. (liters /gram) |
| MV | = | market volume of product. (lbs/year) |
| k | = | conversion constant = 0.115 (gal-gm/liter-lb) or = 0.00354 (gal-gm/fl.oz-lb). |

Applying equation (2) to Barex®210, PET and glass 1 and ½ liter containers in turn and using the NAPCOR data reproduced in Table 3, the total energy requirements for the various container systems are derived in Table 4.

| TABLE 4<br><br>**Total Energy Requirements for Various Containers Using NAPCOR Energy Values and Estimates for Recycling Rates (In MBTU/1000 Gallons)** | |
|---|---|
| **PET** | |
| **1 Liter** | **½ Liter** |
| $E_{AVG}$ = (14.95 x 0.148) + (22.37 x 0.852)<br>= 2.21 + 19.06<br>= 21.27 MBTU/1000 gal | $E_{AVG}$ = (18.62 x 0.148) + (27.85 x 0.852)<br>= 2.75 + 23.73<br>= 26.48 MBTU/1000 gal |
| **GLASS** | |
| $E_{AVG}$ = (23.89 x 0.26) + (26.05 x 0.74)<br>= 6.21 +19.28<br>= 25.49 MBTU/1000 gal | $E_{AVG}$ = (24.94 x 0.26) + (26.98 x 0.74)<br>= 6.48 +19.97<br>= 26.45 MBTU/1000 gal |
| **Barex®210** | |
| $E_{AVG}$ = 22.37 MBTU/1000 gal | $E_{AVG}$ = 27.85 MBTU/1000 gal |
| PET recycling @ 14.8 % ; Glass recycling @ 26% ; Barex®210 recycling @ 0% | |

It is observed that the energy efficiency of both glass and plastic containers decreases, as the containers become smaller.

*(i) Barex®210 Resin bottles versus acrylonitrile/styrene*

A comparative analysis of the impact on energy between the subject copolymer and the competitive acrylonitrile/styrene is not needed because (1) No competition between Barex®210 bottles and acrylonitrile/styrene containers is anticipated.

*(ii) Barex®210 Resin bottles versus glass or other plastics*

Applying equation (1) with appropriate values of CW, MV and material densities yields the values tabulated in Table 5.

**Table 5**

**Final Energy Comparisons For Barex®210 Bottles, Glass and Other Plastic Containers Using Anticipated Market Volume of Ten Million Pounds of Barex®210 Resin**

| 1 Liter | ½ Liter |
|---|---|
| $E_{PET}$ = 21.27 x 1/46.8 x 0.115 x 5.87 x $10^6$<br>= 0.05227 x 5.,87 x $10^6$<br>= 306,800 MBTU/yr. | $E_{PET}$ = 26.48 x 0.5/27.5 x 0.115 x 5.87 x $10^6$<br>= 0.05537 x 5.,87 x $10^6$<br>= 325,000 MBTU/yr. |
| $E_{GLASS}$ =25.49 x 1/(40.3x9.39) x 0.115 x 47 x $10^6$<br>= 0.00774 x 47 x $10^6$<br>= 363,721 MBTU/yr. | $E_{GLASS}$ = 26.45 x 1/(40.3x9.39) x 0.115 x 47 x $10^6$<br>= 0.00803 x 47 x $10^6$<br>= 377,420 MBTU/yr. |
| $E_{BAREX}$ = 22.37x 1/40.3 x 0.115 x 5.0 x $10^6$<br>= 0.0638 x 5.0 x $10^6$<br>= 319,000 MBTU/yr. | $E_{BAREX}$ = 27.85x0.5/(27.5x0.852)x0.115 x 5.0 x $10^6$<br>= 0.06835 x 5.0 x $10^6$<br>= 341,700 MBTU/yr. |

The figures in Table 5 are used along with the approximations and assumptions regarding market volume and the 50/50 glass-plastic competitive replacement to compute the actual energy expenditures. A sample calculation for 1-liter bottles is presented below and inTable 6. Introduction of Barex®210 (1 liter) containers would result in an energy credit of 46,400 MBTU/yr. versus the replaced 1-liter glass containers and an energy deficit of 12,200 MBTU/yr versus the replaced 1-liter PET or similar recyclable containers. The net effect is an energy credit of 34,200 MBTU/yr. from the entry of Barex®210 bottles and equal replacement of glass and plastic containers. The energy saving comes from the combined effect of replacement of glass bottles, which are very energy inefficient versus Barex®210 bottles, and the relatively minor energy addition due to the loss of recycling of PET and similar plastics.

Net = 50%Barex®210 – PET + 50%Barex®210 – GLASS
= 319,000 – 306,800 + 319,000 – 363,721
= (+) 12,200 + (-) 44,721
= (-) 32,521 MBTU/yr.

Table 6 shows the energy requirements for the three scenarios: where Barex®210 bottles compete with 100% with glass containers, 100% with PETcontainers and 50/50 with both glass and PET containers. For example, for the 50/50 replacement scenario,.363,210 MBTU/yr is saved by the use of less glass, and 306,800 MBTU/yr is saved by the use of less PET. The energy cost for Barex®210 bottles is 638,000 MBTU/yr. The net energy saving for this scenario is 34,200 MBTU/yr. Table 6 shows that the energy gain using ½ liter bottles is only about half as much. The energy values with the positive signs indicate added energy burdens; those with the negative signs indicate energy that would no longer be needed. A net energy cost is predicted only when Barex®210 totally replaces other plastic containers in this market niche. This is not likely to occur, but if it were to occur, it entails a very small relative energy cost.

**Table 6**

**Comparison of Energy Requirements in MBTU/yr. For Barex®210 And Competitive Containers**

| Container | | 100% Glass Replacement | 100% PET Replacement | 50%/50% Replacement |
|---|---|---|---|---|
| PET | 1 liter | N/A | (-) 613,600 | (-) 306,800 |
| | ½ liter | | (-) 650,000 | (-) 325,000 |
| GLASS | 1 liter | (-) 727,442 | N/A | (-) 363,721 |
| | ½ liter | (-) 754,840 | | (-)377,420 |
| BAREX | 1 liter | (+) 638,000 | (+) 638,000 | (+) 638,000 |
| | ½ liter | (+) 683,400 | (+) 683,400 | (+) 683,400 |
| NET | 1 liter | (-) 89,442 | (+) 24,400 | (-) 32,521 |
| | ½ liter | (-)71,440 | (+) 33,400 | (-)19,020 |

## 11. MITIGATING MEASURES:

No significantly adverse impacts have been identified for the proposed action, and therefore no mitigation measures are necessary.

## 12. ALTERNATIVES TO THE PROPOSED ACTION:

No significantly adverse impacts have been identified for the proposed action.

## 13. PREPARED BY:

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## 14. CERTIFICATION:

The undersigned officials certify that the information presented is true, accurate, and complete to the best of the knowledge Keller and Heckman LLP and the BP Chemical Company.

Signature of the responsible official(s) responsible for preparation of the environmental assessment

Robert J. Scheuplein
Keller & Heckman LLP

Oct 14, 1999
DATE

Nancy Kutz
BP Chemicals Inc.

October 15, 1999
DATE



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