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Extensive Study of the PVC Industry: Relation of the processing time and processing temperature to the degree of fusion, as well as a strategic plan for increasing consumer demand

Erick Jason Comeaux

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Relation of the processing time and processing temperature to the degree of fusion, as well as a strategic plan for increasing consumer demand

A Thesis

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by
Erick Jason Comeaux
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Part I

Fusion Study of Polyvinyl Chloride (PVC): Relation of the Processing Time and Processing Temperature to the Degree of Fusion

Summary

Several polyvinyl chloride(PVC) compounds were prepared in a Haake Torque Rheometer, equipped with noninterchangeable rotors and an electrically-heated mixing head, at various processing times and processing temperatures, with a constant rotor speed of 60 rpm. A Seiko 220C Automatic Cooling Differential Scanning Calorimeter (DSC) was then used to characterize the degree of fusion of these compounds. Afterwards, a Cambridge 260 Scanning Electron Microscope (SEM) was used to study the morphological characteristics of these compounds. In this paper, a correlation has been established between the processing time and processing temperature and the degree of fusion of these PVC compounds.

Introduction

PVC is the second most produced plastic in the world, and its industry is currently growing at a steady rate of approximately 3% per year. This polymer has provided a strong competitor for materials such as wood, metal, paper and other plastics for the last 20 to 40 years. Vinyl siding, pipe fittings, garden hoses and electrical wire insulation are among PVC's most common applications.[1]

Ultimately, the goal of this research is to understand the correlation between the fusion characteristics and the mechanical properties of PVC compounds. This knowledge can then be applied to the extrusion process in order to develop formulations that will optimize the mechanical properties of PVC compounds in various demands. This particular study focuses upon the relationship between the processing time and the processing temperature and the

degree of fusion of PVC compounds.

The suspension polymerization process is the primary route to preparing PVC in industry today. Batch mixers, such as Brabender and Haake Rheometers, are frequently used in research applications because of their flexibility while experiencing frequent product and formulation changes.[2]

As depicted in figure 1, three stages of morphology exists in PVC powder: stage I, stage II and stage III. Stage III particles are known as PVC grain particles and are visible to the naked eye; they are approximately 100-150μm in diameter. Stage II particles, known as microparticles, compose stage III particles, and because they are loosely packed, they give the PVC grain particles a porous nature. The stage II particles are 1-2μm in diameter. Finally, stage I particles, known as submicroparticles, are found in stage II particles and are 100-300Å in diameter. Stage I particles exhibit 5-10% crystallinity. The significance of these stages of morphology lies in their role in determining the mechanical properties of PVC. In order for PVC to have good mechanical properties, the grain boundaries must be eliminated and part of the microparticles must be destroyed so that they can be compacted. During further interfusion of the PVC, the boundaries between the submicroparticles disappear, and the PVC grains from a 3-D network, known as the gelation, or fusion, of PVC.[4, 5]

Currently, various additives, such as stabilizers, process aids, impact modifiers, fillers, lubricants and plasticizers, are widely used in the PVC industry. The primary purpose of

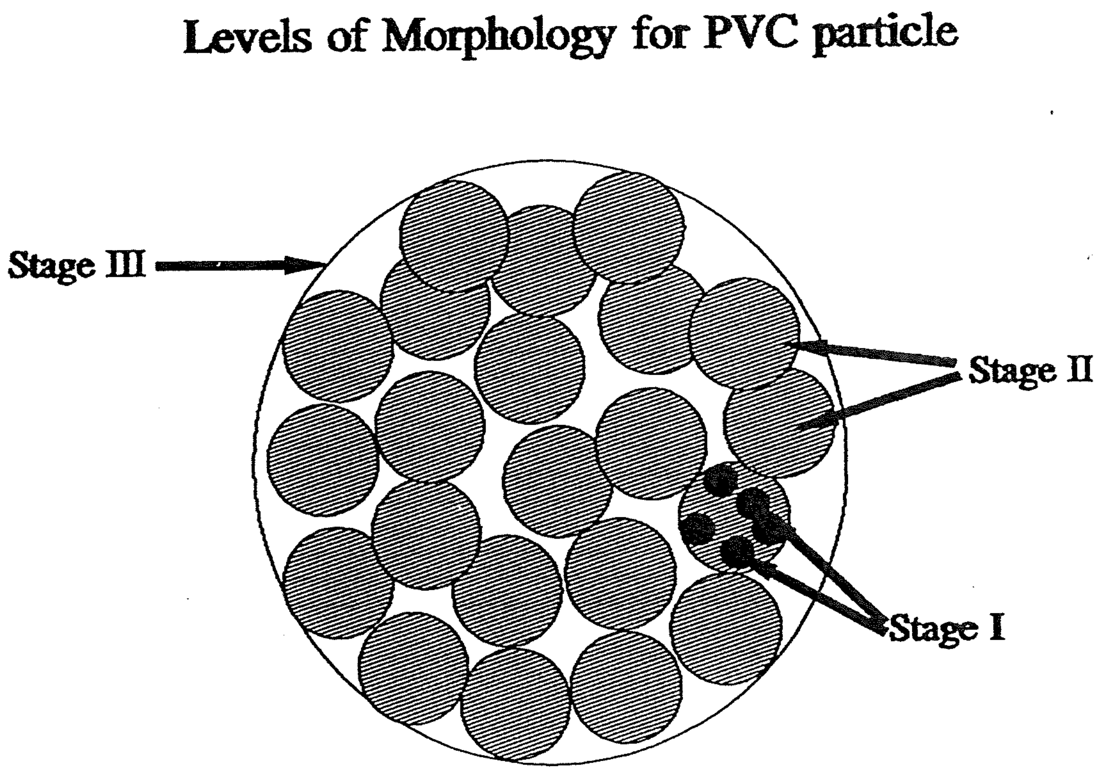


Figure 1: The three stages of morphology that exist in a PVC grain particle. [3]

stabilizers, process aids and lubricants is to facilitate the processing of PVC compounds. The other additives, however, are used to modify the physical properties of the final plastic product. For example, impact modifiers are elastomeric materials that limit the propagation of cracks within the plastic.[6] Plasticizers, on the other hand, have a broad range of applications. They are usually dipolyesters or tripolyesters that are based upon phthalic, trimettalic or adipic acids. Additionally, plasticizers must have very low, or negligible, volitilities and must be compatible with PVC in varying extents, based upon the character and proportion of the plasticizer. Figure 2 contains a chart which displays several applications for Exxon's Jayflex plasticizers.

Although these additives are very effective compounds, they are also very costly. For instance, several additives are often added to PVC compounds as a means of formulating multiple specific properties. If, however, the physical properties of PVC could be influenced by controlling the degree of fusion, then these costs would be drastically reduced. The result would be lower product costs to consumers and higher profitability for the PVC industry.

In this study, DSC thermal analysis was used to characterize the degree of fusion of PVC compounds because of its convenience and the fact that DSC provides a quick, quantitative measurement of the degree of fusion. The main disadvantage of DSC lies in the fact that, due to the small sample weight of 10 mg, some poorly dispersed additives may interfere with the final results.

The intent of this study is to understand how processing

PLASTICIZER	TYPICAL APPLICATIONS
Phthalates	General Purpose* Strong Solubility Low Volatility Low Temperature Low Diffusivity
Trimellitates	Low Volatility* Low Temperature Low Diffusivity
Aliphatic dibasic esters	Low Temperatures*
Phosphates	Flame Resistant* Strong Solubility Low Temperatures
Epoxides	Stabalizer* Low Volatility Low Temperature
Polyesters	Low Diffusivity* Low Volatility*
Extenders	General Purpose* Low Temperature
Miscellaneous	Strong Solubility* Low Volatility* Low Diffusivity*

(NOTE: * = Primary Function)

Figure 2: Typical applications of Exxon's Jayflex Plasticizers.[7]

temperature and processing time affect the degree of fusion of PVC compounds in a Haake Torque Rheometer. Additionally, a relationship will be established between the morphology and the degree of fusion of these compounds, as well as between the processing temperature and fusion time of the PVC compounds.

Experimental

Preparation of the PVC compounds

The PVC was prepared via suspension polymerization and was supplied by the Dow Chemical Company. The PVC masterbatch powder contained 100 parts of PVC grain particles, 1.5 parts of processing aid (K120N), 1.0 parts of wax (XL165), 1.0 parts of calcium stearate, 1.5 parts of heat stabilizer (T-137).

Several PVC compounds were prepared in a Haake Torque Rheometer (Rheocord 90) equipped with an electrically-heated mixing head and noninterchangeable rotors. These PVC compounds were prepared at various processing times and various processing temperatures, specifically, at 160, 170, 180, 190 and 200°C, and blending times of 1, 3, 5, 7 and 8 min. The rotor speed was 60 rpm, and the sample weight was 65g.

Differential Scanning Calorimetry (DSC) thermal analysis

The PVC compounds prepared in the Haake Torque Rheometer were cut randomly, and each sample was prepared to be approximately 10mg. The degree of fusion was characterized by a Seiko 220C Automatic Cooling Differential Scanning Calorimeter (DSC), based on the heat of fusion (mJ/mg). Using DSC, the samples were heated from 25°C to 270°C, at 20°C/min. Three measurements were made for

each sample so that an average value for the heat of fusion could be calculated.

Scanning Electron Microscopy (SEM) analysis

A Cambridge S-260 Scanning Electron Microscope (SEM) was used. The samples were immersed in liquid nitrogen for 45 seconds, broken and coated with 200Å gold-palladium film. Only the centers of the broken surfaces were examined.

Results and discussion

Haake Torque Rheometer

A typical curve obtained from the Haake Torque Rheometer, such as figure 3, contains five significant locations. The portion of the curve between the loading point (L) and the stopping point (S) is the processing time. The portion of the curve between L and the fusion point (F) is defined as the fusion time (FT), and is the most important portion of the graph. Point O on the graph is the point at which the PVC compound begins to degrade, and point D is the actual degradation point. At this point the PVC forms hydrochloric acid (HCl). PVC that has been processed to this point is black and very porous. Therefore, the stopping point is usually located between points L and O in order to prevent this degradation.

When comparing several curves from the Haake Rheometer, such as in figure 4, it is noticed that, as the processing temperature increases, for any given time, the fusion time decreases. A graphical representation of this phenomenon is in figure 5. The PVC compound prepared at 200°C for 7 min had a dramatically lower

Haake Rheocord90

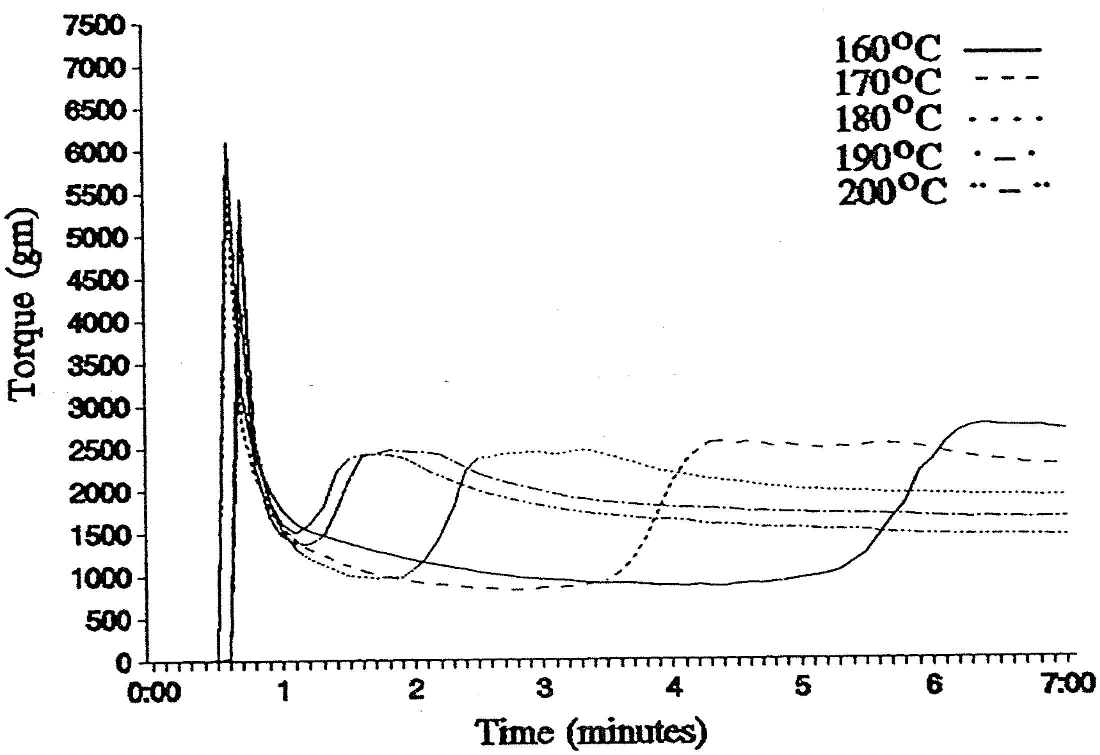


Figure 4: An overlapp of several curves from the Haake Torque Rheometer, displaying a decrease in the fusion time.

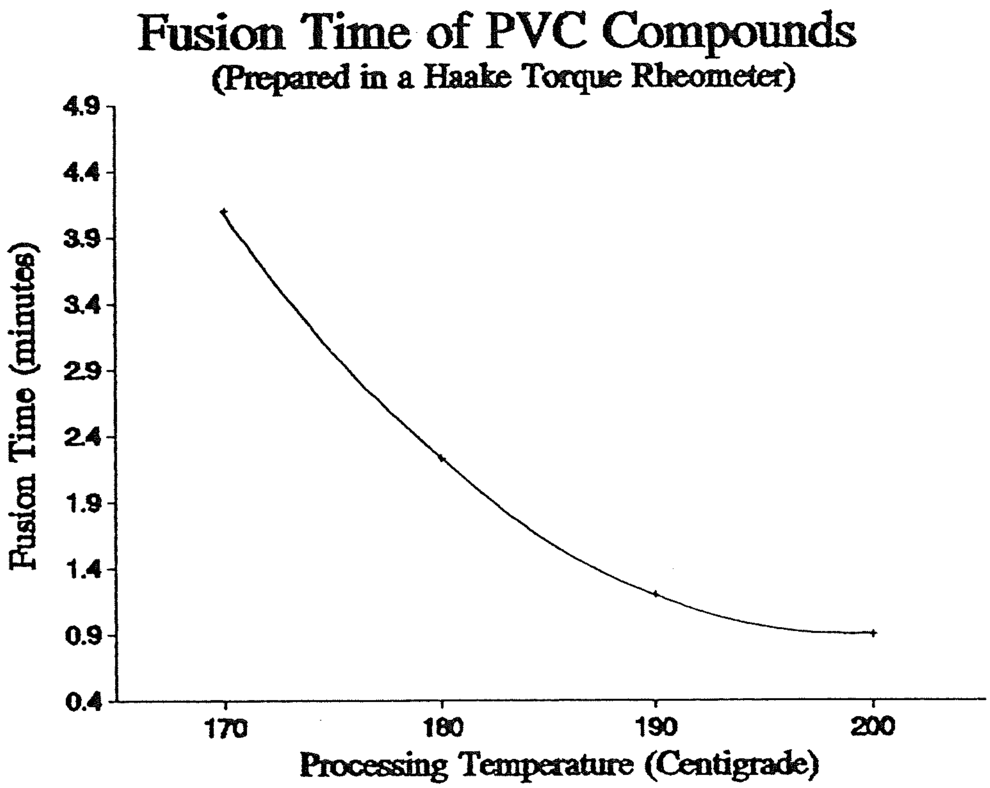


Figure 5: The relationship between the processing temperature and the fusion time of PVC compounds.

fusion time than that prepared at 160°C for 7 min. This is most likely because a higher thermal energy input causes interfusion among the PVC submicroparticles to form a 3-D network at a faster rate.

Differential Scanning Calorimetry (DSC) thermal analysis

Figure 6 contains the DSC traces obtained in this study. Each DSC curve displayed a glass transition temperature (T_g) at approximately 85°C, and an endothermic baseline shift occurred at this temperature. Two significant peaks were noticed: peak A and peak B. Peak A represented the endothermic energy of the PVC crystals melted in the Haake Torque Rheometer and then recrystallized during cooling. Peak B represented the endothermic energy of the PVC crystals not melted in the Haake Torque Rheometer. The endothermic energy contained in peak A was used as a quantitative measure for the degree of fusion. In order to determine the relative degree of fusion for each PVC compound, the heat of fusion for the unprocessed PVC compound (0 mJ/mg) and the PVC compound processed at 200°C for 8.5 min (13.72 Mj/mg) were taken as 0% and 100% degrees of fusion, respectively.[8]

Samples with a low processing time or temperature had no, or a very small, peak A and a very large peak B. When comparing the various DSC curves, it was noticed that with increasing processing times and temperatures, peak A expanded and peak B shrunk. Another observation was that, as the processing temperature increased, peak B shifted to a higher temperature. As seen in figures 7 and 8, as processing time and temperature increased, the degree of fusion also increased.

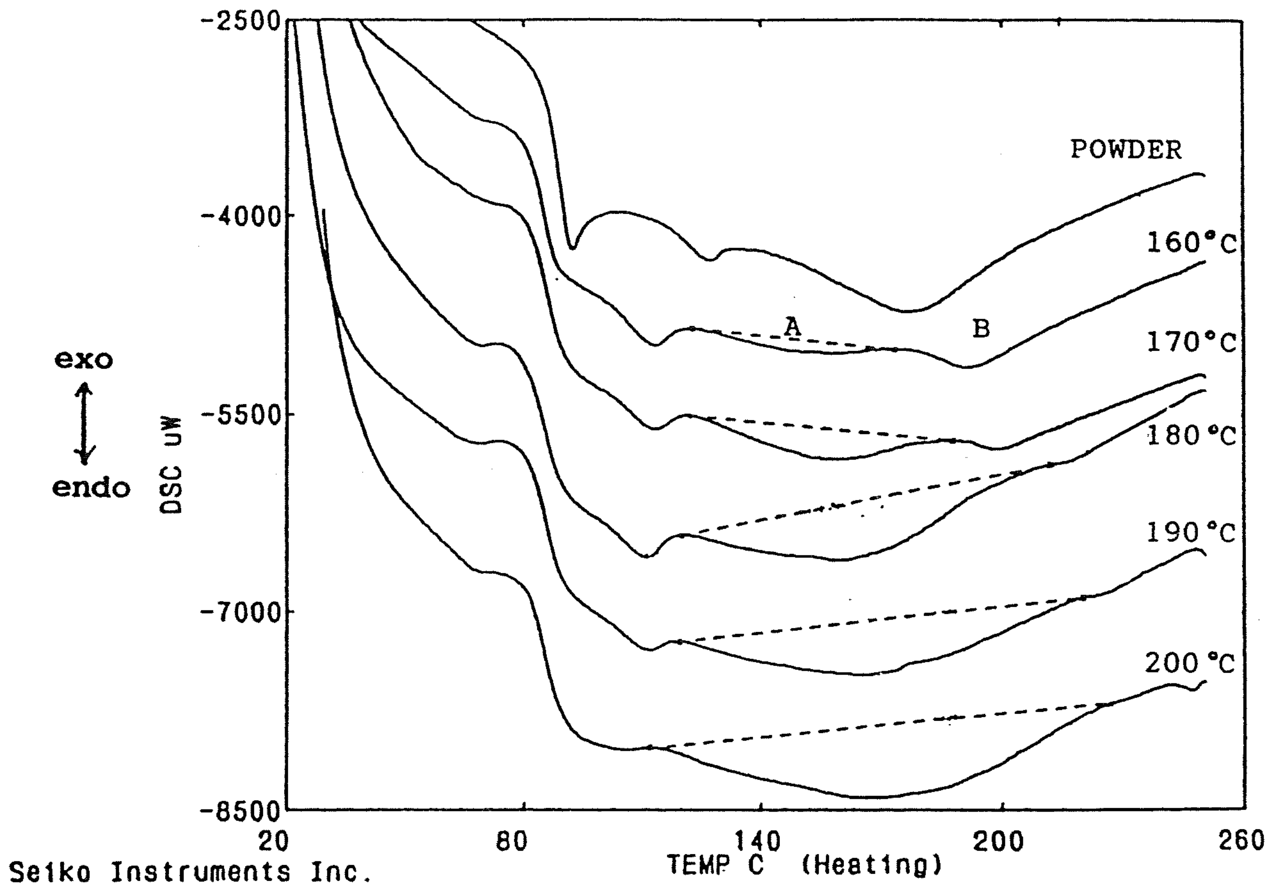


Figure 6: A sample of the DSC traces obtained for the PVC compounds.

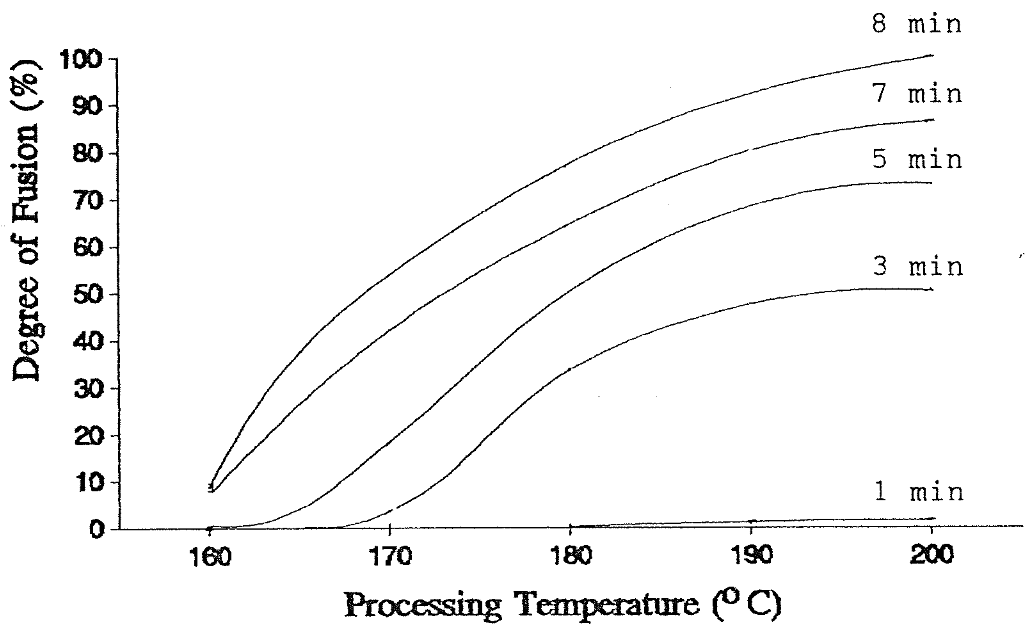


Figure 7: The relationship between the processing temperature and the degree of fusion of PVC compounds.

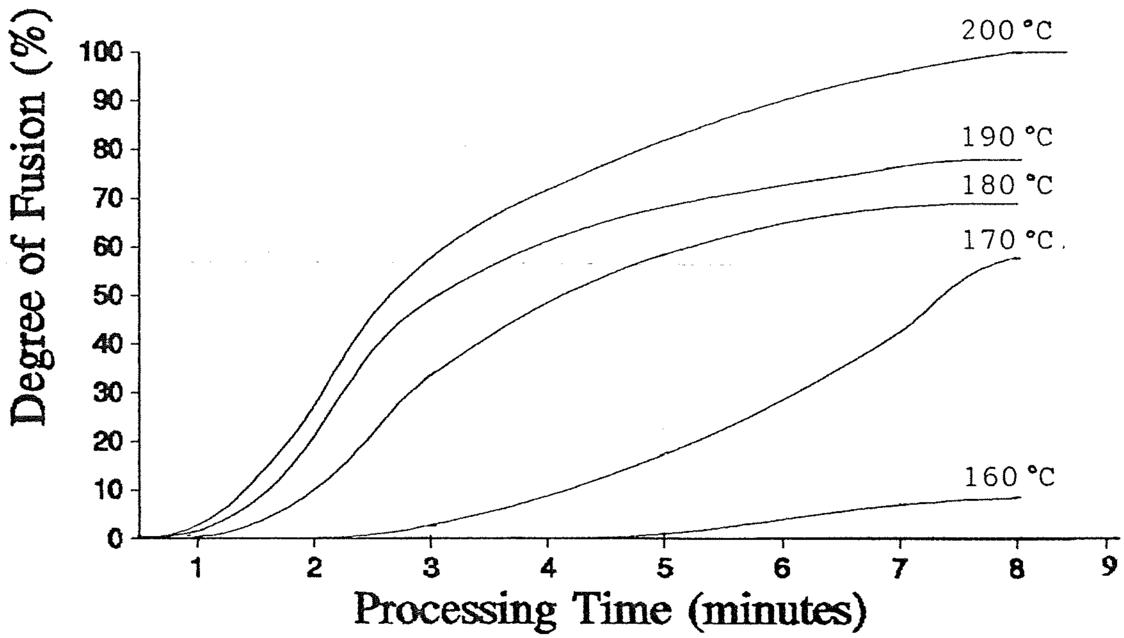


Figure 8: The relationship between the processing time and the degree of fusion of PVC compounds.

Scanning Electron Microscopy (SEM) analysis

SEM analysis provided informative visual aids to study the morphology of the PVC compounds. Figure 9 contains some of the SEM micrographs. A PVC grain particle is seen in figure 9 I. The grain particle was rounded and had a very porous surface. This PVC grain particle (stage III particle) was approximately 100-150μm in diameter. The PVC compound prepared at 160°C for 7 min had a very poor degree of fusion (refer to figure 9 II). The texture was very rough and non-continuous, and the interfusion was not strong enough to form a smooth, 3-D network. The PVC compound prepared at 170°C for 7 min had a slightly better degree of fusion. The discontinuity had been reduced in many areas; large crevasses did still occur, but they were confined to smaller areas. The PVC compound prepared at 180°C for 7 min had a much improved degree of fusion (refer to figure 9 III). Some holes did still appear, but the harsh crevasses were eliminated. A stronger level of interfusion was noticed. The PVC compound prepared at 190°C for 7 min had a still higher degree of fusion than that of previous samples. The texture is still not smooth, but is much more continuous. There were no drastic changes when moving on to the PVC compound prepared at 200°C for 7 min, but a slightly higher fusion level was noticed. The PVC compound prepared at 200°C for 8 min was used as the standard for a degree of fusion of 100% (refer to figure 9 IV). A much higher degree of fusion was noticed with a much smoother continuity. The stronger interfusion between the PVC particles caused a much smoother 3-D network of the polymer chains to be formed in this sample. Because the distribution of

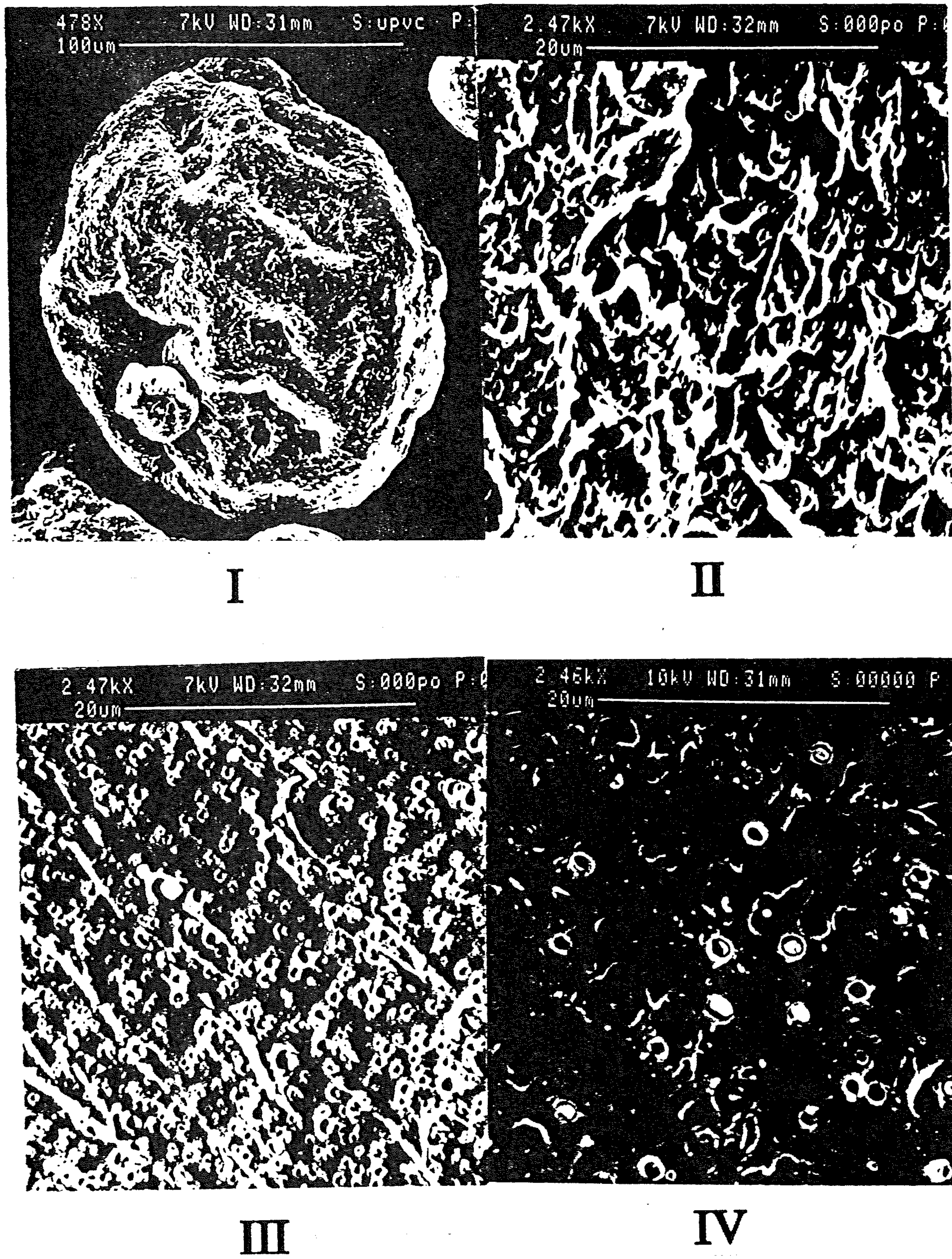


Figure 9: A sample of the SEM micrographs obtained in this study.

energy in the Haake Torque Rheometer was not very uniform, some PVC primary particles were observed in all samples.

Conclusions

At a constant rotor speed of 60 rpm, as the processing temperature and processing time of the PVC compounds increased, the degree of fusion of the PVC compounds also increased. Furthermore, as the processing temperature increased, for a given processing time, the fusion time decreased. Due to a higher thermal energy input, at higher processing temperatures, interfusion between PVC microparticles caused the formation of a 3-D network among polymer chains at a much faster rate. At lower temperatures, such as 160°C, this 3-D network is very poor and discontinuous. Conversely, at higher temperatures, such as 200°C, this 3-D network is very strong and smooth.

Part II

Business/Marketing Analysis
of the
PVC Industry

Summary

A small-scale consumer confidence campaign was designed for local plastic industries to utilize in improving consumers' attitudes towards plastic products. The marketing objective of this campaign was to convince 60% of local consumers that "plastic is good for society" within 6 weeks. Initially an analysis of the PVC industry was conducted, and the market trends were examined. A survey was then conducted within a control group to measure current consumer attitudes regarding plastic. Next, advertisements and promotional articles were designed which attended to the consumers' most popular concerns and misconceptions. Samples of these advertisements were distributed to the control group, and a questionnaire was used to measure their effectiveness. The ultimate goal of this campaign is to supplement the National Plastics Council's mass promotional efforts to boost the consumer confidence level regarding plastic, and hence, increase the sales of PVC.

Introduction

The PVC industry has been a great financial asset to the United States by creating numerous permanent jobs and contributing approximately $4 billion to the economy each year. Furthermore, it has been observed that this industry is growing at a consistent rate of about 3% per year.[9]

According to Donald Goodman, some of the reasons for the industry's growth include the following considerations:

(1) Cost/Performance Factors
(2) Versatility
(3) Innovative Compounding Technologies
(4) Effective Marketing Strategies
(5) Wealth of Manufacturing Experience

(6) Good Adaptability to Government Regulations
(7) Environmentally Friendly for Solid Waste Management [10]

Because of its versatility, PVC has played an important role in many industries ranging from common household items to life-saving medical supplies. The construction industry has benefitted from PVC's durability in the form of vinyl siding and lumber, and its safety in the form replacing the dangerous lead piping once found in homes. Electrical wire insulation has also been made possible by PVC, providing for the safe distribution of electricity to homes and businesses. PVC has also become a common household item in the forms of food wraps, lawn furniture, shower curtains, rain coats and shoe soles. Even the medical industry relies upon PVC in the form of blood bags and other storage containers.

In addition to supplying society with many needed products, PVC has also offered consumers a wide range of more environmentally conscious materials. As the world's population grows, the demand for building supplies and furniture rises. Being that these products primarily consists of wood, this increase in demand places a hardship upon the world's forests. PVC has buffered this burden by offering a substitute for wood that is recyclable, although it may be a difficult task, and more durable. For instance, a broken wooden product must many times be discarded; whereas, plastic can be melted and reformed into the same product.[11]

On the other hand, a list of the factors which have hindered the growth of PVC include other low-cost, competitive resins, performance limitations, environmental control costs and political attacks. In addition to being the world's second most produced

plastic, PVC is also the single most regulated plastic resin in the United States. The PVC polymer chain is 56% chlorine by weight, placing it in the spotlight for attacks from environmental groups and lobbyists. Much of this is attributed to an incident in 1974 when cancer found in many plant workers was linked to the vinyl chloride found in PVC reactor scrapers. This lead to many lawsuits in the 1980's regarding the toxic gases that are released when burning PVC and the current claim that PVC manufacturing is the world's largest source of dioxin. Toxicologists have reviewed these claims and have reported that both dioxins and furans are also produced in the burning of wood, which is common to many industries and households. In fact, the Society of Plastic Engineers, the American Medical Association, the American Chemical Society and the Society of Toxicology do not support the Environmental Protection Agency's position regarding chlorine and chlorine-based products. Unfortunately, these facts are rarely made available to the public. Instead, radical environmentalists continue to spread such propaganda as "no organo-chlorine compounds are found in nature." As a matter of fact, nature constantly produces such organo-chlorine compounds as chloromethane, trichloromethane, carbon tetrachloride, hydrochloric acid, chlortetracycline and pentachlorophenol.[12, 13, 14]

Despite PVC's position of being the second most produced plastic in the world, the PVC industry has often been subjected to sharp criticism from market analysts due to its cyclic nature. These analysts claim that specialty plastics, such as ABS, are

immune to such business cycles. Unfortunately, business cycles are uncontrollable financial factors that affect every product industry, including specialty plastics, such as ABS. Figure 10 supports this theory by displaying several market trends of the thermoplastics industry. As the plots illustrate, the PVC industry displays trends which are very similar in nature to other thermoplastic industries. The "high value" curve represents the market value of ABS plastic. The observed trend in this curve provided evidence that specialty products are, indeed, subject to the influence of business cycles. Additionally, the similarity noticed in the trends is a strong indication that the factors which influence the PVC industry also affect most other plastic markets.[16]

Fortunately, although business cycles are inevitable, their effects on a market can be managed if their causes are identified. Contrary to popular belief, stock market activity and interest rates are not reliable indicators of a market's downturn. This is due to the fact that stock market behavior and interest rates are dependent upon the accuracy of market analysts' predictions. An incorrect prediction often causes investors to loose confidence in the market, leading to a significant drop in stock prices. This decline in stock value is independent of a market's actual growth or contraction. A perfect example of this situation occurred in the fall of 1987 when a harsh downfall was observed in the stock market. During this period, the PVC industry maintained a very healthy market value. In fact, it was not until 1990 that the

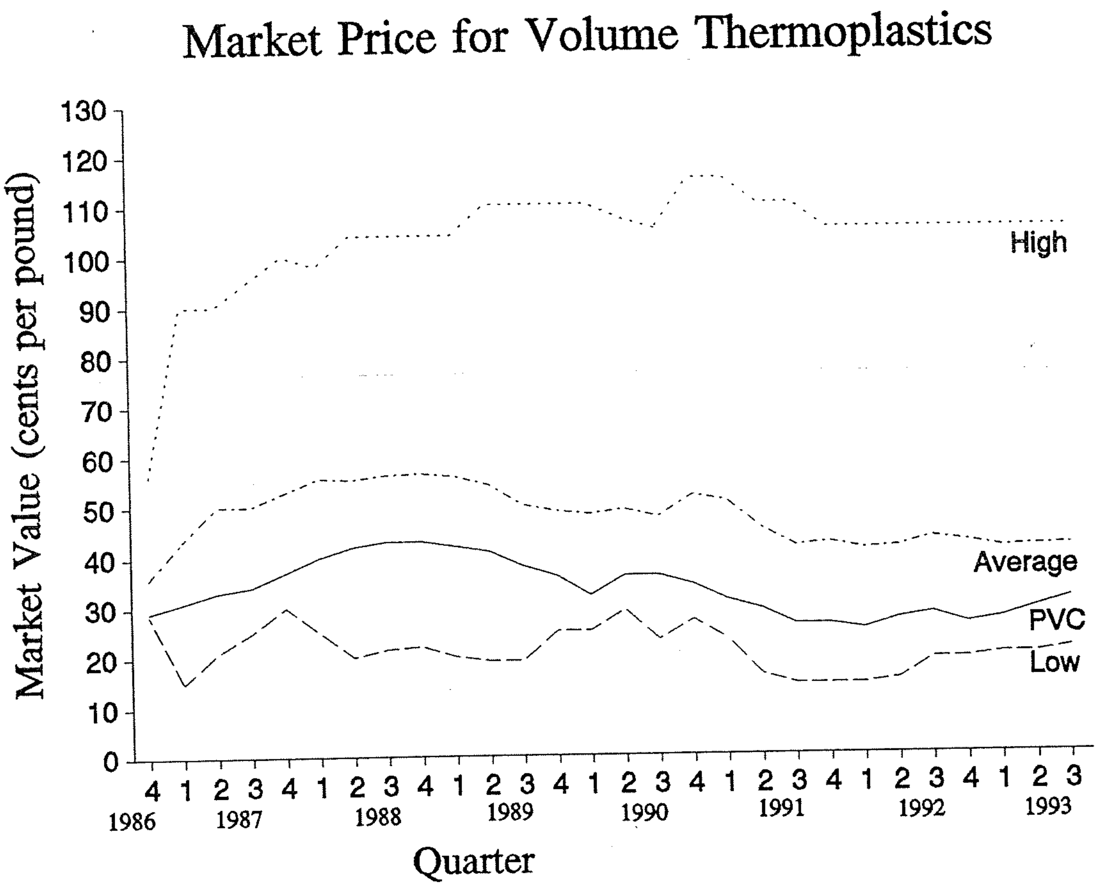


Figure 10: Quarterly market prices for volume thermoplastics from 1986 to 1993.

industry became less profitable, due to an increase in competitiveness.[17]

Experimental Method

A control group of 50 consumers (ages 19 to 35) was formed. A survey was then designed to measure the consumers' attitudes towards plastic and to investigate the sources of these attitudes. As figure 11 illustrates, some statements contained negative rewording in order to insure the accuracy of responses. Responses were recorded on a scale of 1 to 5 (1 representing "strongly agree" and 5 indicating "strongly disagree.") The survey was then distributed to all members of the control group, and the responses were recorded. Finally, Microsoft EXCEL was used in analyzing the data collected.

A promotional campaign was then planned to attend to the most popular concerns and misconceptions regarding plastic. Three advertisements were created, each with a unique theme. The first ad, illustrated in figure 12, centered around the theme, "Plastic...growing to meet the needs of you and your loved ones." Some of the plastic industry's most notable accomplishments are mentioned, causing the reader to consider plastic's irreplaceable niche in society. The second ad, found in figure 13, highlights the plastic industry's impact on the economy. This ad reminds consumers that plastic creates many jobs in the local community and generates an abundance of tax revenue for community programs. The third ad, depicted in figure 14, was designed as a form of damage control to counteract the damaging image that environmental groups have formed for plastic.

The purpose of this survey is to measure consumers' attitudes towards plastic and the sources of these attitudes.

	Strongly Agree 1	2	3	4	Strongly Disagree 5
I like plastic.	1	2	3	4	5
Plastic is good for the environment.	1	2	3	4	5
The plastic industry is dangerous for local communities.	1	2	3	4	5
Plastic is more expensive than other materials.	1	2	3	4	5
Plastic is a poor quality material.	1	2	3	4	5
I would like to see less plastic used in products.	1	2	3	4	5
Plastic provides a good substitute for other materials.	1	2	3	4	5
Plastic piping is better than lead piping in homes.	1	2	3	4	5
Plastic is more durable than wood.	1	2	3	4	5
I avoid the use of plastic whenever possible.	1	2	3	4	5
Plastic provides a good substitute for natural resources (i.e. wood).	1	2	3	4	5
Plastic is good for the medical industry.	1	2	3	4	5
I am very knowledgeable about plastics.	1	2	3	4	5
Plastic is 100% recyclable.	1	2	3	4	5
The plastic industry creates many jobs for local communities.	1	2	3	4	5
Plastic is irreplaceable in the medical industry.	1	2	3	4	5
Plastic improves the quality of life.	1	2	3	4	5
Plastic products are over-priced.	1	2	3	4	5
Plastic is good for society.	1	2	3	4	5

Most of my knowledge about plastic comes from:
(Please check one.)

Newspapers	______
Television(News)	______
Environmental Groups	______
Magazines	______
Scientists/Engineers	______

Figure 11: Questionnaire used to evaluate the initial attitudes regarding the plastic industry.

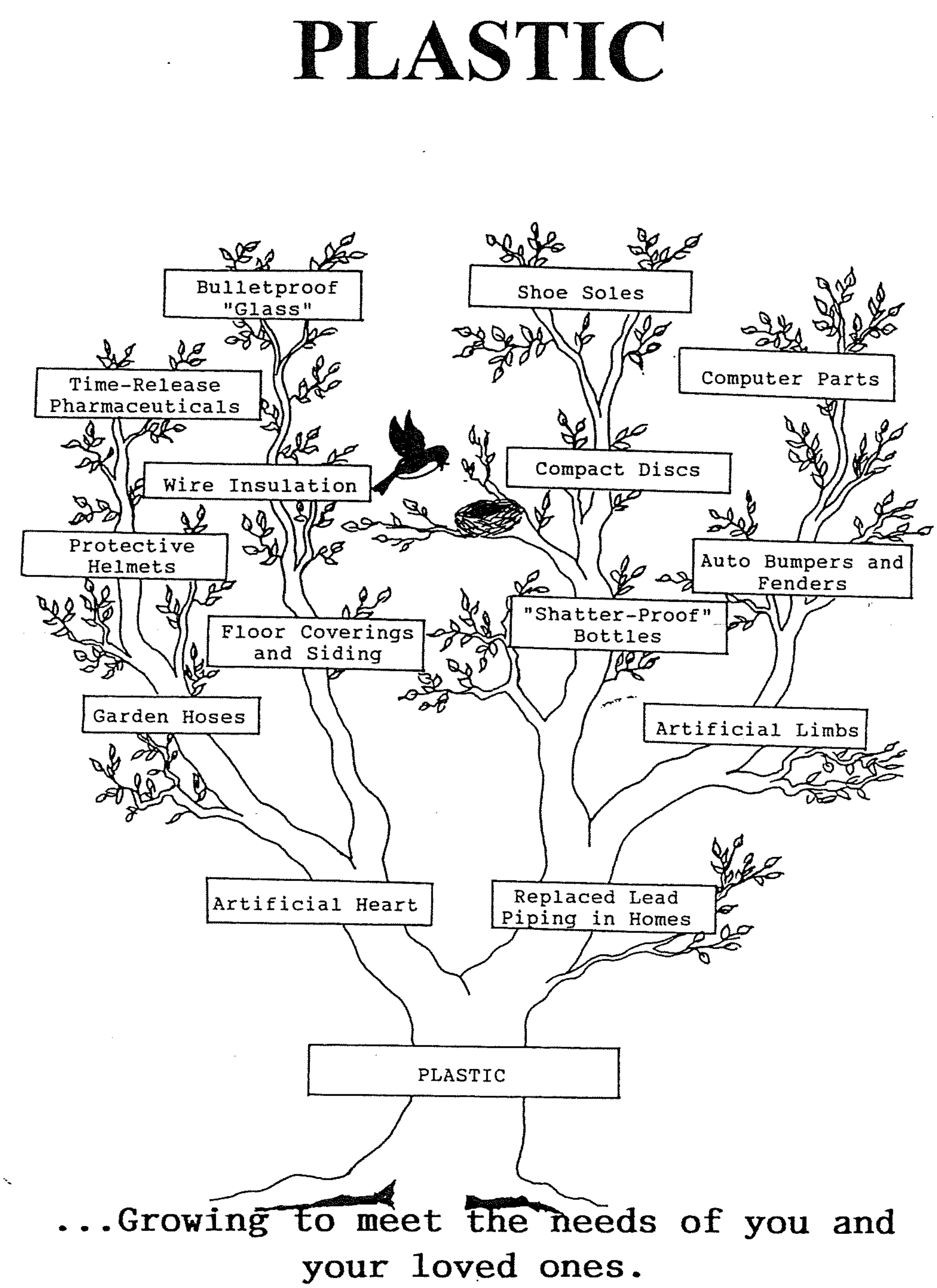


Figure 12: Newspaper advertisement for the first week of the campaign.

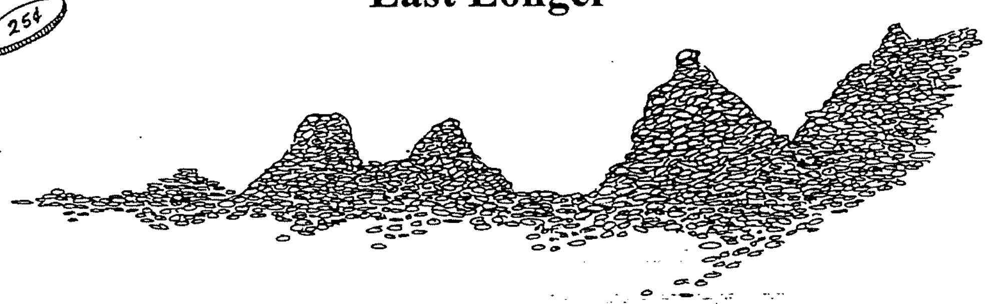
PLASTIC MAKES ¢ENTS!

-Over $4 Billion Contributed to the U.S. Economy Each Year

-Thousands of Local Permanent Jobs Created

-Provides Tax Dollars to Support Community Programs

-Provides Less Expensive Materials That Last Longer



Dont't Let Your Intelligence Be Insulted...

Know The Facts!

A co-founder of Greenpeace has been quoted as stating:
"It's not the truth that matters,
it's what people believe is the truth that matters."

CONSULT YOUR LOCAL LIBRARY AND FIND THE REAL FACTS REGARDING PLASTIC!

Figure 14: Newspaper advertisement for the third week of the campaign.

Another survey, found in figure 15, was devised in order to measure the effectiveness of the advertisements. Samples of the advertisements were distributed to each member of the control group, along with a copy of the survey. The responses were scaled in the same manner as the first survey on a scale of 1 to 5. Once again, Microsoft Excel was utilized in analyzing the collected data.

Summary of Results

Figure 16 contains a summary of the responses obtained from the first survey. According to these findings, consumers are not necessarily opposed to the use of plastic. On a scale of 1 to 5 (1 denoting a positive attitude and 5 indicating a negative attitude) the individual consumers' averages ranged from 1.684 to 2.947. These averages, however, only provide a very narrow analysis of the results. In order to appreciate the wealth of information found in the data, the responses must be studied in closer detail. Distributions, trends and correlations were examined and the knowledge obtained was then applied when planning the campaign.

Although neutral attitudes do not necessarily depict negative feelings, they do present a potential danger. New information can easily transform neutral attitudes into negative opinions. In order to prevent this kind of disaster, "inoculation techniques" are often used in marketing. The purpose of these methods is to present consumers with information that will convert negative attitudes into positive opinions before any damaging beliefs are formed.

The purpose of this survey is to measure the effectiveness of the previous advertisements and to determine the best means of distributing these ads.

	Strongly Agree				Strongly Disagree
	1	2	3	4	5
The ads caught my attention.	1	2	3	4	5
The ads contained information that I was not previously aware of.	1	2	3	4	5
The ads caused me to consider new information.	1	2	3	4	5
The ads had no effect on my perceptions towards plastic.	1	2	3	4	5
Plastic piping is better than lead piping in homes.	1	2	3	4	5
I plan to avoid the use of plastic whenever possible.	1	2	3	4	5
Plastic is good for the economy.	1	2	3	4	5
Plastic is good for society.	1	2	3	4	5
I feel that plastic is a good advancement in technology.	1	2	3	4	5
I read the "Sunday Advocate" on a regular basis.	1	2	3	4	5
The ads did not present any new information to me.	1	2	3	4	5
Plastic is good for the environment.	1	2	3	4	5
I find these ads to be trust-worthy.	1	2	3	4	5
Plastic helps to make life better.	1	2	3	4	5
I would like to see less plastic products in the future.	1	2	3	4	5
I read my local newspaper weekly.	1	2	3	4	5
The plastic industry helps local communities.	1	2	3	4	5
The ads were not very effective.	1	2	3	4	5
Compared to other materials, plastic is too expensive.	1	2	3	4	5
Plastic is beneficial for many industries.	1	2	3	4	5

Figure 15: Questionnaire used to evaluate the effectiveness of the campaign.

The purpose of this survey is to measure consumers' attitudes towards plastic and the sources of these attitudes.

	AVG
I like plastic.	2.286
Plastic is good for the environment.	3.286
The plastic industry is dangerous for local communities.	2.943
Plastic is more expensive than other materials.	2.286
Plastic is a poor quality material.	2.200
I would like to see less plastic used in products.	2.486
Plastic provides a good substitute for other materials.	2.057
Plastic piping is better than lead piping in homes.	1.943
Plastic is more durable than wood.	2.400
I avoid the use of plastic whenever possible.	2.000
Plastic provides a good substitute for natural resources (i.e. wood).	2.514
Plastic is good for the medical industry.	1.771
I am very knowledgeable about plastics.	3.914
Plastic is 100% recyclable.	1.943
The plastic industry creates many jobs for local communities.	2.314
Plastic is irreplaceable in the medical industry.	2.400
Plastic improves the quality of life.	2.143
Plastic products are over-priced.	2.829
Plastic is good for society.	2.343

Most of my knowledge about plastic comes from:
(Please check one.)

Newspapers..................	14%
Television News..............	57%
Environmental Groups.........	6%
Magazines....................	9%
Scientists/Engineers.........	14%

Do you know the difference between PVC, polyethylene, polypropylene and polystyrene? Yes...14% No...86%

Figure 16: Summary of results from first survey (initial perceptions.)

The data obtained strongly indicated that an effective campaign must recognize the importance of inoculation theory. Distributions of response frequencies were generated for each individual question. These distributions were examined, and the most critical threats towards consumers' perceptions were identified. These primary threats concerned environmental, economic and educational issues.

The first two distributions (figures 17 and 18) are related to consumer's responses towards environmental issues. When asked if plastic was good for the environment, the greatest number of consumers indicated that they possessed a neutral attitude. It was also observed, however, that the positive and negative sides of this neutral attitude did not balance. A greater number of respondents felt that plastic was not good for the environment, compared to those who felt that plastic was environmentally friendly. The second distribution illustrates how respondents felt about the plastic industry operating in local communities. Once again, the greatest number of consumers held a neutral opinion. It was also noticed, however, that a significant number of respondents felt that the plastic industry is, indeed, dangerous for local communities. In fact, if half of those holding neutral attitudes are persuaded into forming negative beliefs, almost 50% of the population will feel that the industry is unsafe for local communities. On the other hand, converting only half of the neutral attitudes into positive beliefs will result in a 54% majority feeling that plastic companies are safe for local

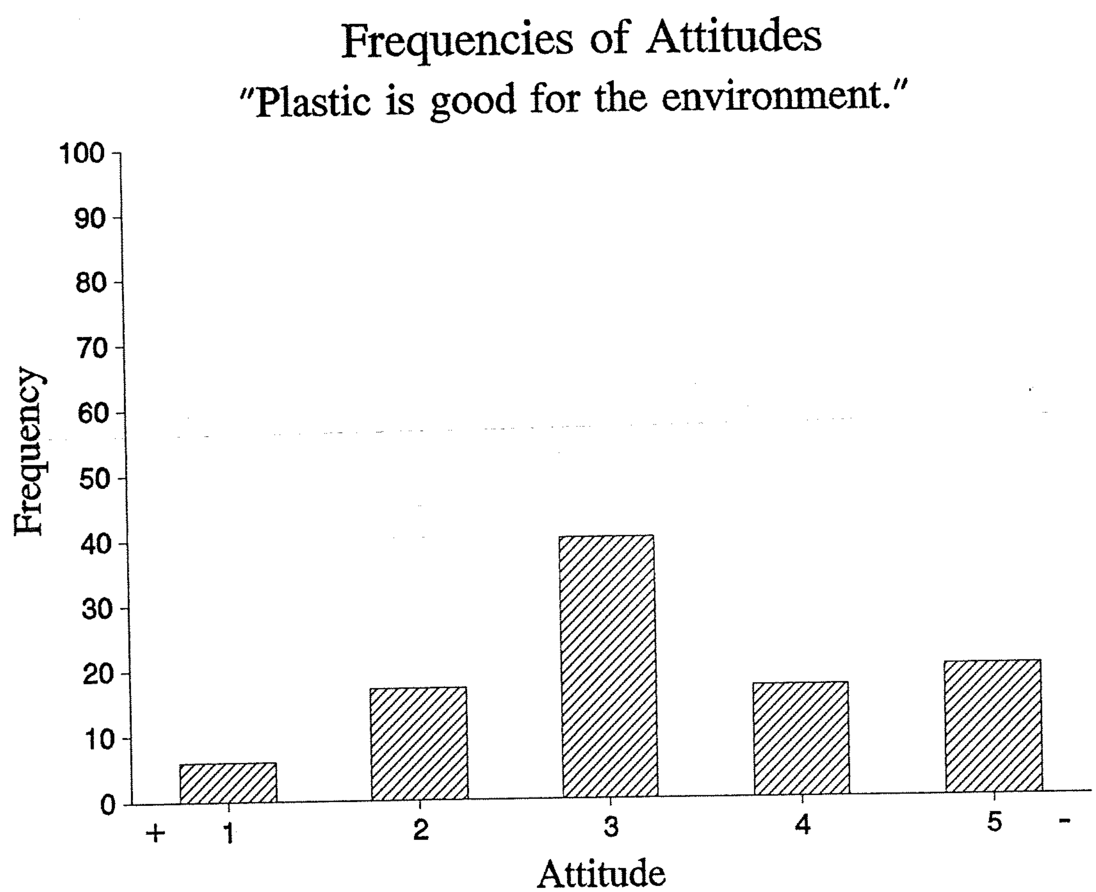


Figure 17: Frequencies of attitudes regarding environmental issues.

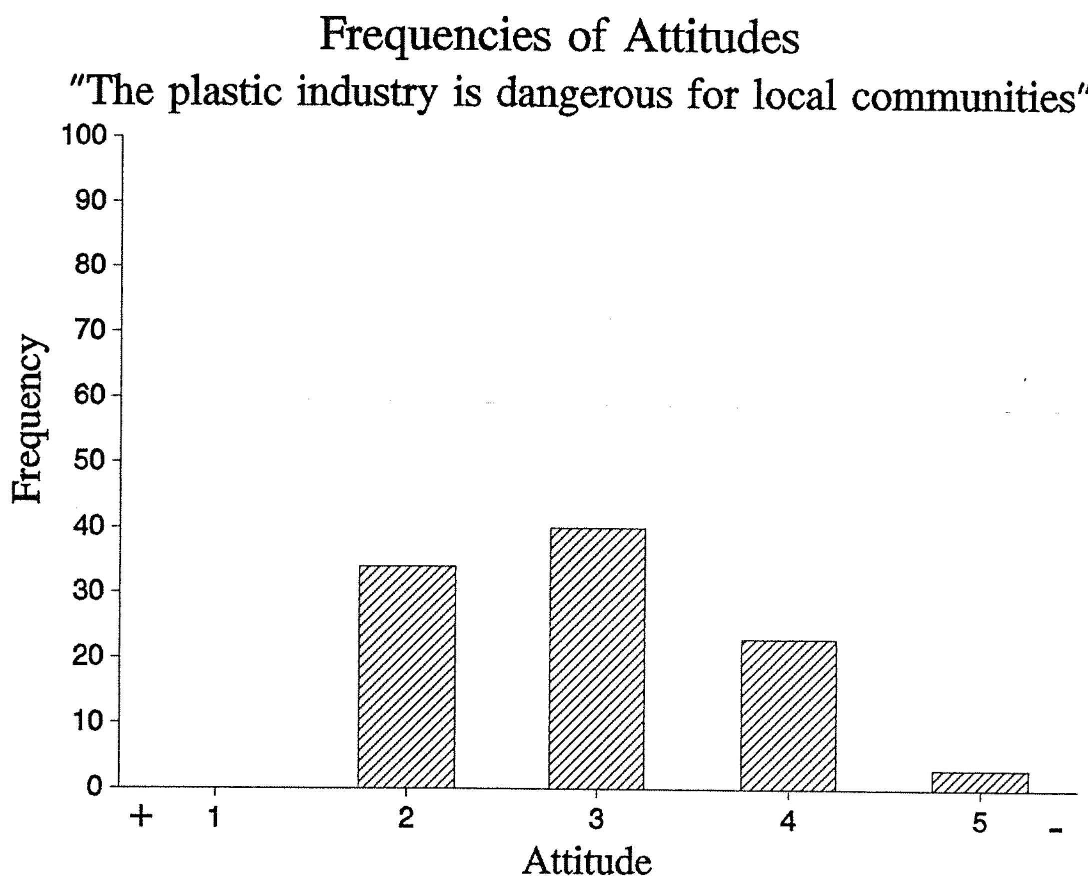


Figure 18: Frequencies of attitudes regarding community issues.

communities.

Although the first two distributions identified a potential threat to the plastic industry, the third distribution (figure 19) illustrates an excellent opportunity. Of the consumers surveyed, 45% agree that plastic provides a good substitute for natural resources. This value could easily be increased to 70% by convincing half of those possessing a neutral position that plastic is an ideal substitute for finite natural resources, such as lumber.

The fourth distribution (figure 20) indicated that most consumers are not confident that plastic is priced at a good value. 51% of those surveyed displayed a neutral opinion; whereas, only 33% felt that plastic products are not over-priced. This again presents an ideal opportunity for the plastic industry to generate supportive beliefs among its consumers. A well-planned campaign must persuade consumers that plastic is an excellent value because of its durability and its environmental implications.

The next plot (figure 21) is in direct relationship to the campaign objective of convincing 60% of all consumers that "Plastic is good for society." The distribution indicated that 54% of the consumers surveyed currently agree with this statement. Therefore, in order to meet the ultimate goal of this marketing plan, the campaign must be aimed to convert 16% of the neutral opinions into positive attitudes.

As mentioned earlier, the use of inoculation theory was critical in the design of this campaign. Figure 22 illustrated

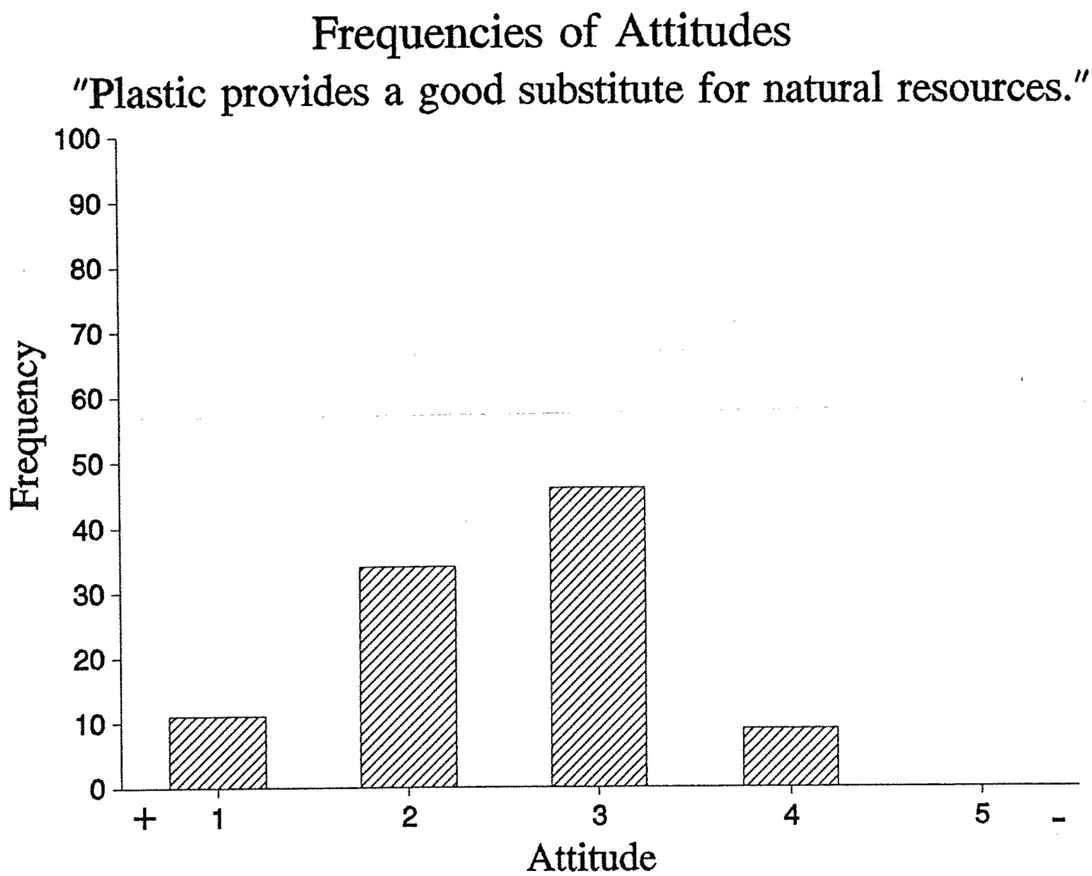


Figure 19: Frequencies of attitudes regarding the usefulness of plastic as a substitute for natural resources.

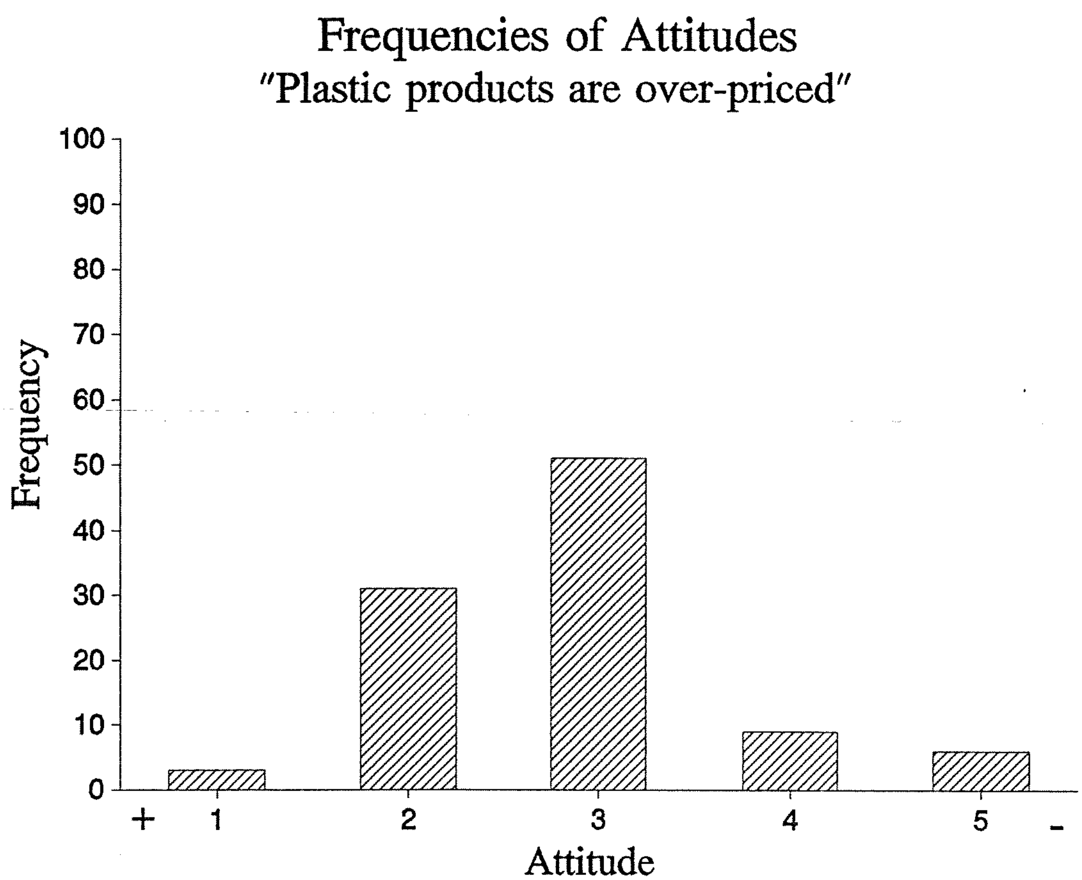


Figure 20: Frequencies of attitudes regarding the price of plastic.

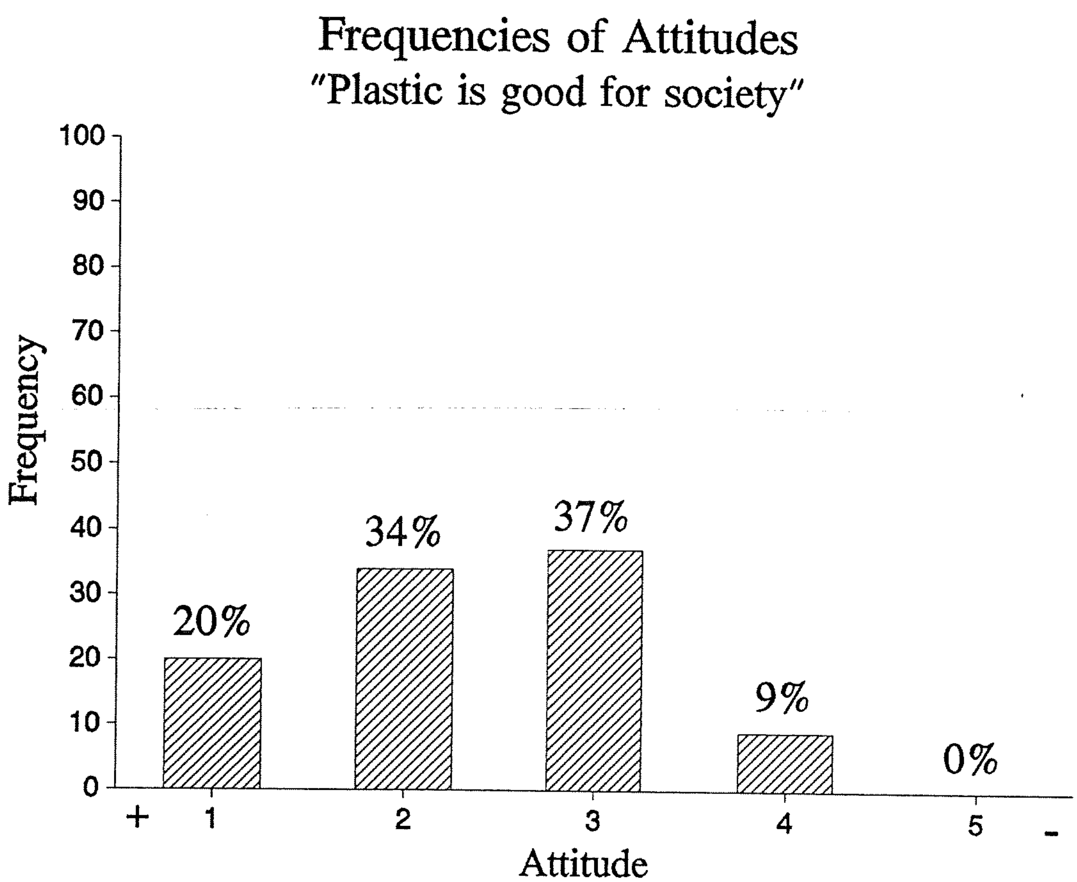


Figure 21: Frequencies of attitudes regarding the primary objective of this campaign.

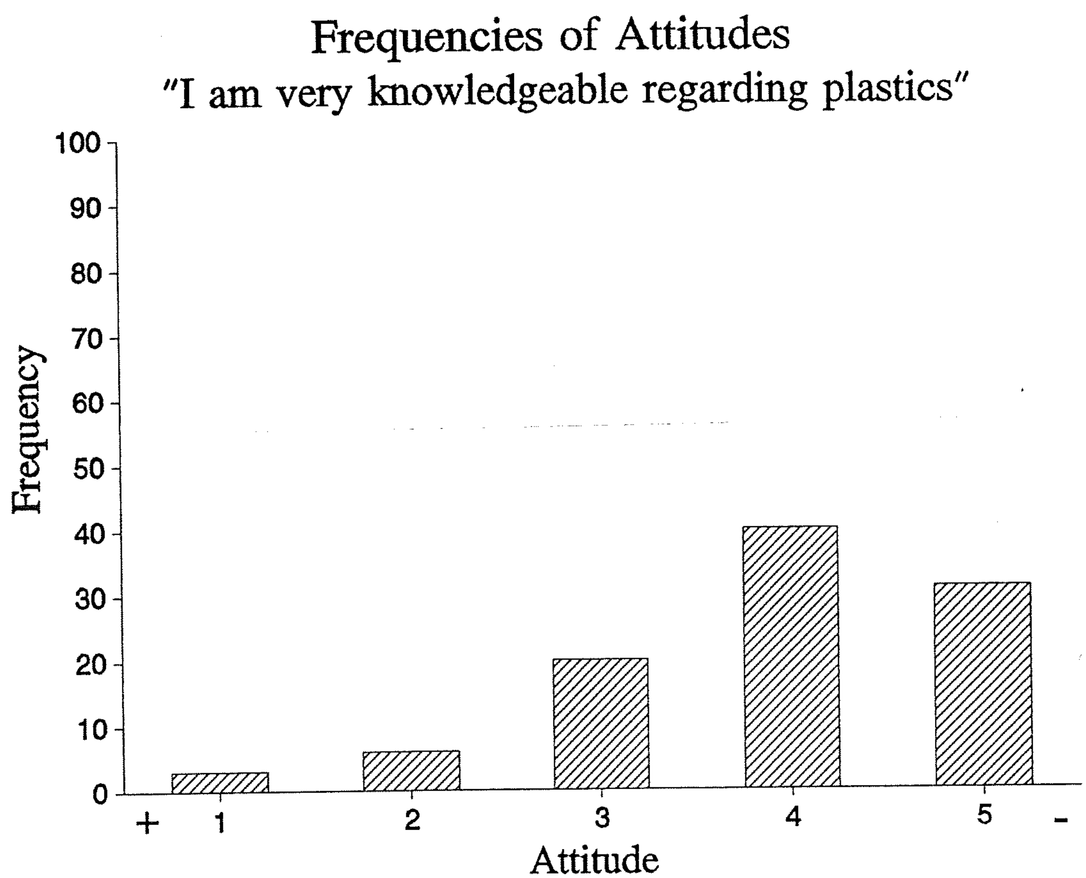


Figure 22: Frequencies of attitudes regarding the amount of knowledge consumers' possess about plastic.

that the majority of consumers (71%) do not consider themselves to be very knowledgeable regarding plastic. This was supported by the fact that 86% of those surveyed did not know the difference between 4 major types of plastic (refer to figure 23). Consumers must be presented with factual, accurate and trustworthy information so that they may form educated opinions regarding the plastic industry. This campaign was designed to accomplish that goal in the most effective and efficient manner possible.

The results of the second survey are located in figure 24. According to these findings, inoculation theory was, indeed, a beneficial tool in the design of this campaign. Once again, the simple response averages obtained from this survey do not provide a sufficient amount information. Therefore, the distributions, trends and correlations were examined.

In the first survey, neutral attitudes were cited as presenting a plausible danger in several areas. These areas included environmental, financial and educational concerns. As the following 4 figures illustrate (figures 25, 26, 27, 28 and 29), this campaign improved consumers' perceptions in all of the critical domains. Figures 25 and 26, concerning environmental and community issues, indicated that 58% of consumers felt that plastic was good for the environment. It was also observed that 71% of the consumers surveyed believed that the plastic industry helps local communities. Furthermore, figure 27 indicated that 63% of the respondents disagreed with the statement that plastic is too expensive. Most importantly, 71% of the consumers demonstrated

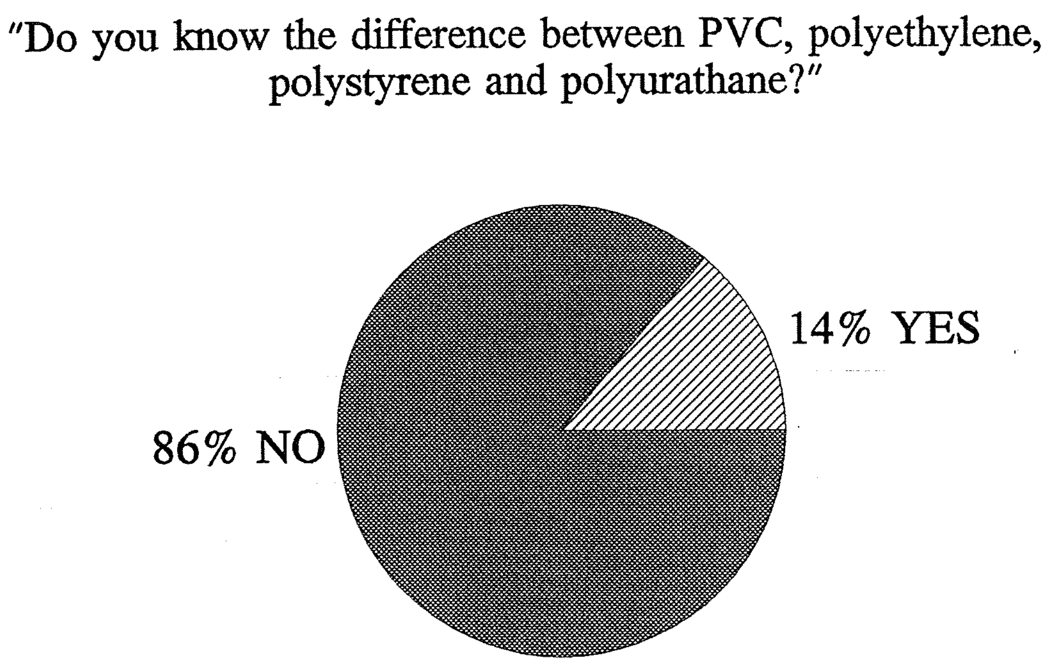


Figure 23: Consumers' awareness regarding the different types of plastic.

The purpose of this survey is to measure the effectiveness of the previous advertisements and to determine the best means of distributing these ads.

	Average
The ads caught my attention.	2.316
The ads contained information that I was not previously aware of.	2.368
The ads caused me to consider new information.	2.632
The ads had no effect on my perceptions towards plastic.	2.868
Plastic piping is better than lead piping in homes.	2.289
I plan to avoid the use of plastic whenever possible.	2.211
Plastic is good for the economy.	2.053
Plastic is good for society.	2.180
I feel that plastic is a good advancement in technology.	2.211
I read the "Sunday Advocate" on a regular basis.	2.658
The ads did not present any new information to me.	2.368
Plastic is good for the environment.	2.500
I find these ads to be trust-worthy.	2.395
Plastic helps to make life better.	2.263
I would like to see less plastic products in the future.	2.211
I read my local newspaper weekly.	2.421
The plastic industry helps local communities.	2.158
The ads were not very effective.	2.474
Compared to other materials, plastic is too expensive.	2.184
Plastic is beneficial for many industries.	2.355

Figure 24: Results of the questionnaire used to evaluate the effectiveness of the campaign.

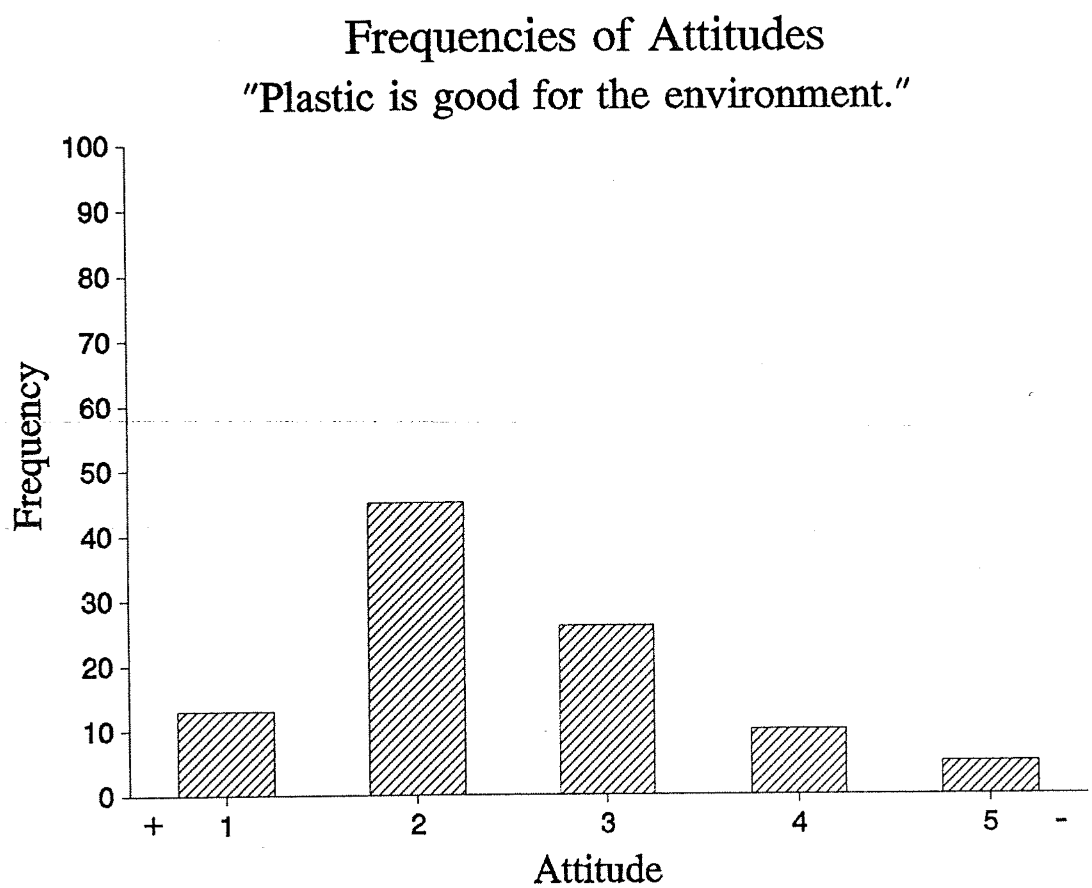


Figure 25: Frequencies of attitudes regarding environmental issues after exposure to the advertisements.

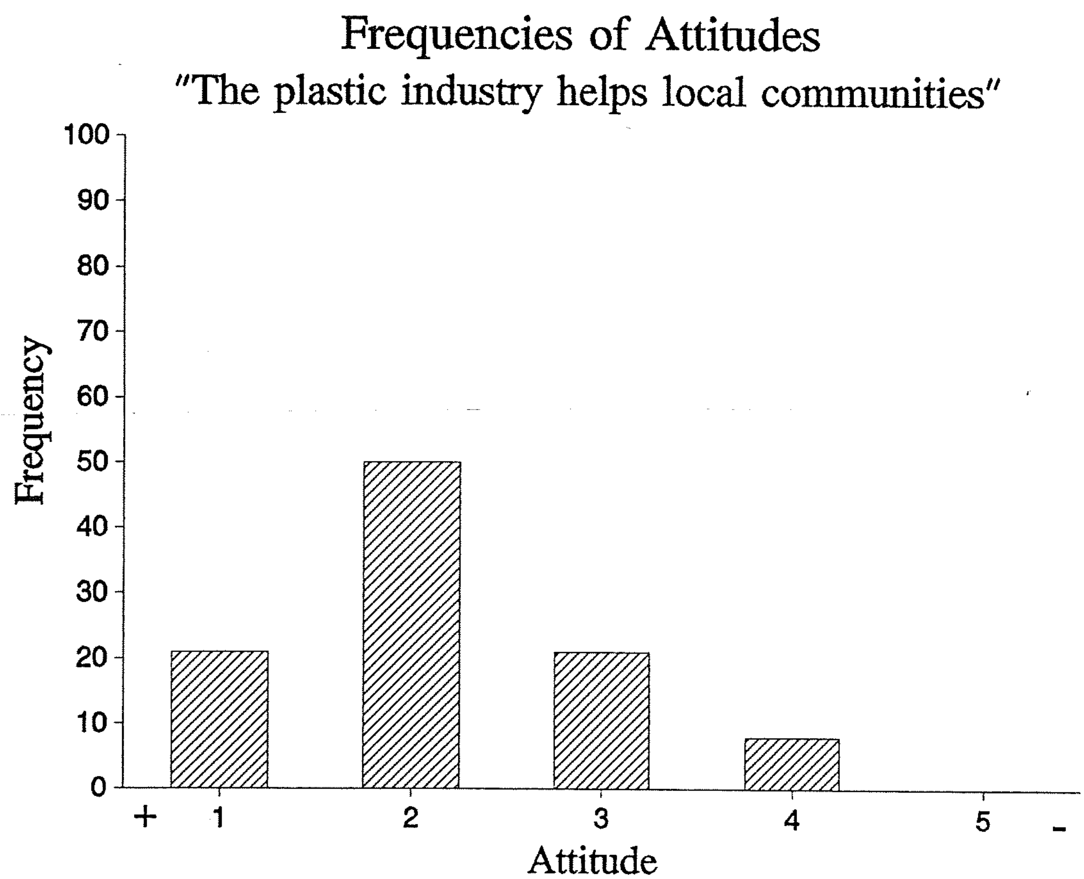


Figure 26: Frequencies of attitudes regarding community issues after exposure to the advertisements.

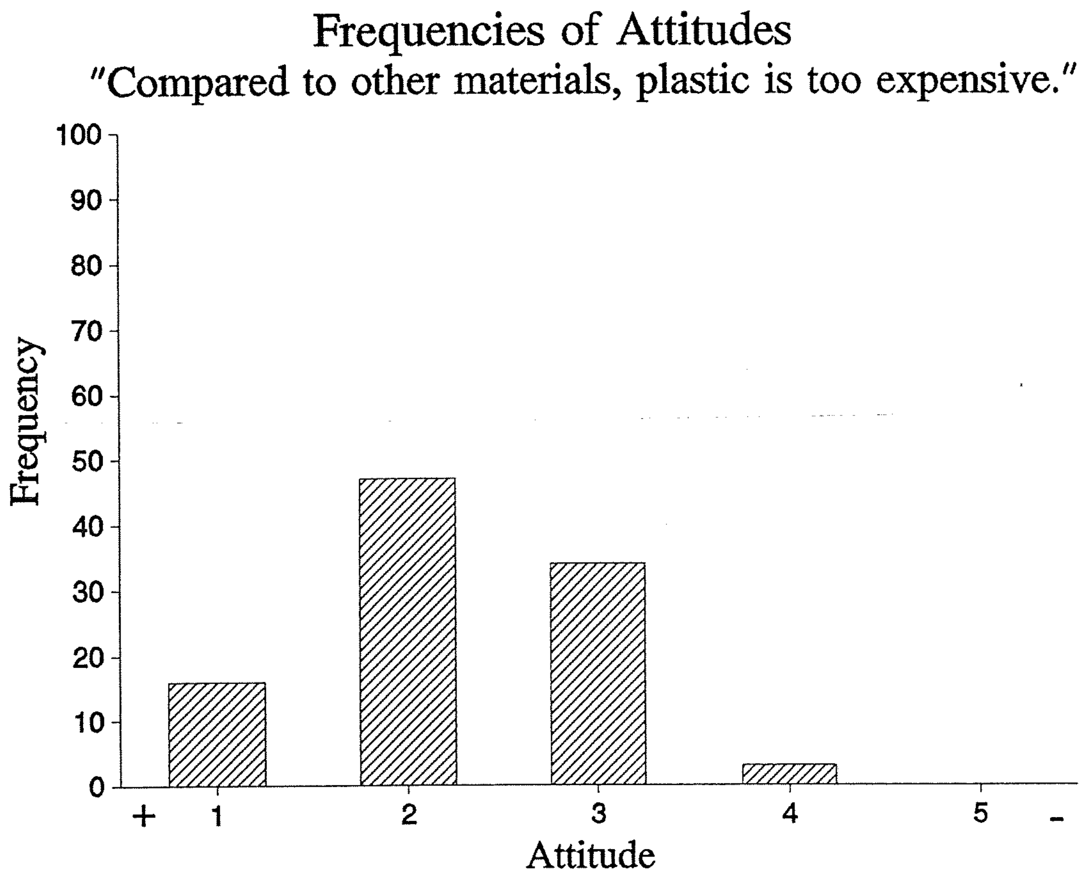


Figure 27: Frequencies of attitudes regarding the price of plastic after exposure to the advertisements.

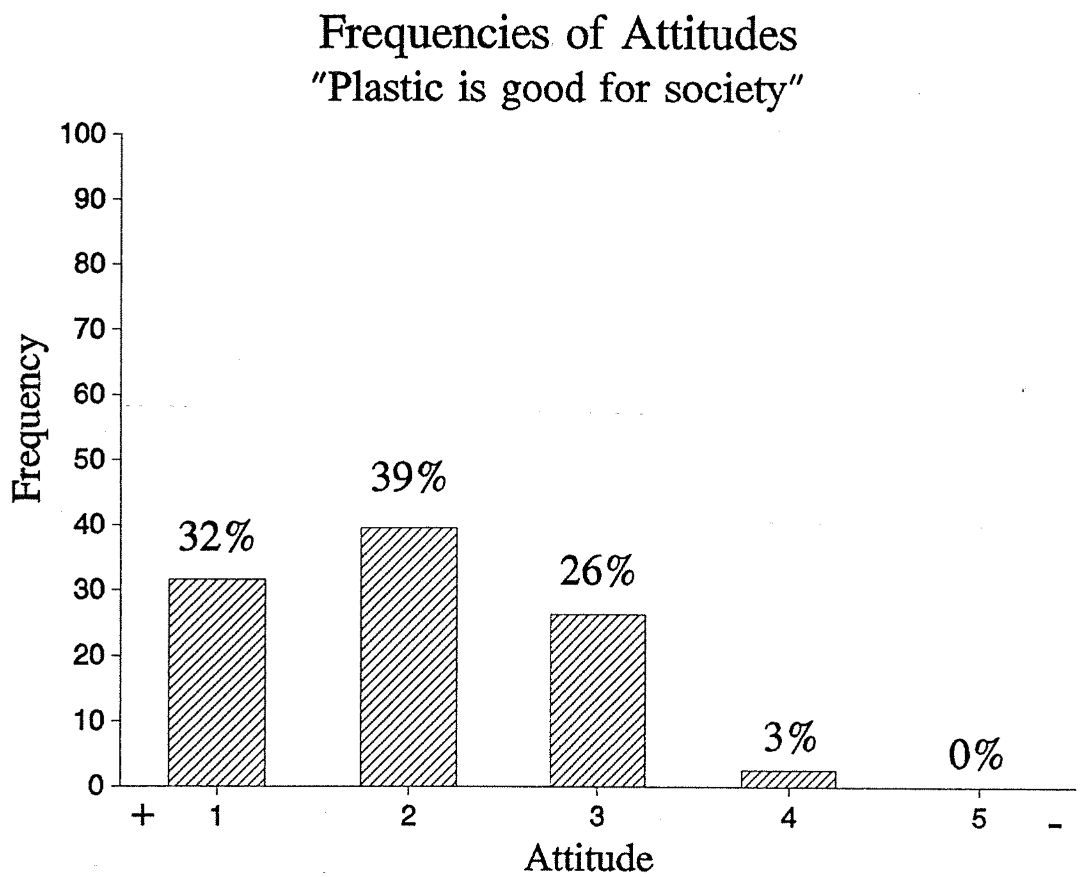


Figure 28: Frequencies of attitudes regarding the primary objective of this campaign after exposure to the advertisements.

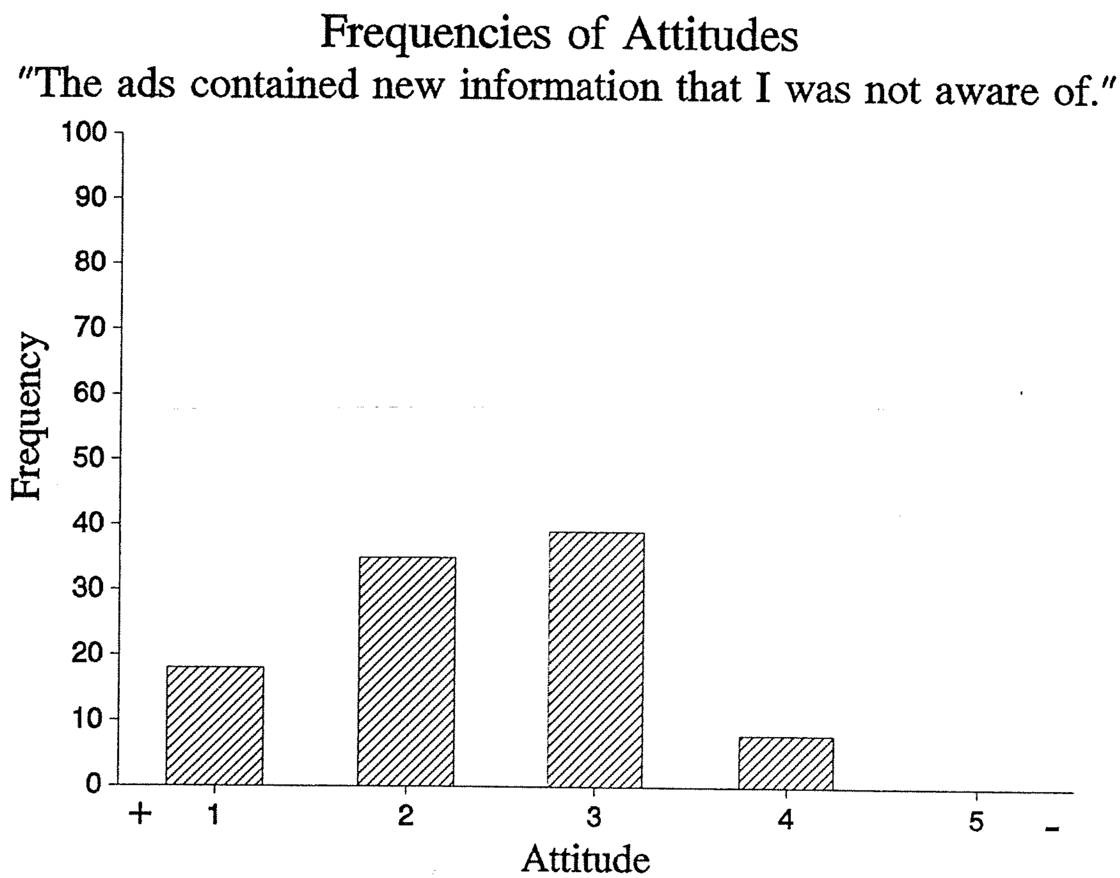


Figure 29: Evaluation of the information presented in the advertisements.

that they agreed with the statement "Plastic is good for society" (refer to figure 28). Thus, the marketing objective was accomplished. It was also verified in figure 29 that the advertisements contained valuable information that helped consumers to make more educated and informed decisions regarding plastic.

Conclusion

In conclusion, a small-scale consumer confidence campaign was designed for local plastics industries to utilize in improving consumers' attitudes towards plastic products. This campaign was an ideal supplement for the National Plastics Council's mass media campaign, and can easily be implemented by such local organizations as the Society of Plastics Engineers.

The first step in the campaign is to conduct a random survey to measure the current consumer attitudes regarding plastic. Next, three half-page newspaper advertisements are released on a pulsing schedule for 5 weeks (1 ad circulated every other week). These advertisements should be placed in major newspapers, such as Baton Rouge's "Sunday Advocate." The cost of such advertisements is approximately $2,500.00 per advertisement, but an audience of over 375,700 consumers can be expected. Therefore, the CPM(Cost Per Thousand) for this campaign is only $6.65. During the "off-weeks," when no major advertisements are displayed, letters should be written to local newspapers as "Guest Editorials." These letters should mirror the many positive influences that the plastic industry has had upon the local community. Items such as taxes, jobs and community programs generated by local companies should be

highlighted. It has been proven that these articles can have a significant impact upon consumers' perceptions because they are the most trustworthy form of advertising. Finally, the effectiveness of the campaign can be measured by re-distributing the first survey randomly. Consumers' responses before and after the campaign should be compared, and some "tailoring" may be applied to the program to address the needs of specific geographical regions.

Ultimately, the result of the program should reflect that 60% of local consumers believe that "plastic is good for society" within 6 weeks. However, this study indicated that an improvement of 17 percentage points is possible, with a final measure of 71% of local consumers feeling that "plastic is good for society."

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