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Food Contact Polymers Case Study

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Job Number: J14635-0

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March 21, 2019

The following test was performed:

1. Standardized Gel Permeation Chromatography (GPC)

Objective

The goal of this study was to demonstrate the importance of GPC in the analysis of commercially available food contact plastics. Herein, 3 main food contact polymers, namely polyethylene, hot melt glue, and polyethylene terephthalate were analyzed by standardized Gel Permeation Chromatography (GPC), an analytical service offered at Jordi Labs.

Summary of Results

Three (3) food contact polymers were analyzed by GPC. The results are summarized in **Table 1-3.**

Background

Food contact polymers consist of any polymer that is used to manufacture materials intended to come in contact with food such as kitchenware, food packaging and containers, electrical devices, and more.[1] Food contact polymers consist of polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, ethylene vinyl acetate, polyamide, polyesters, and more. Herein, we have analyzed 3 main polymers, namely polyethylene, ethylene vinyl acetate, and polyethylene terephthalate using gel permeation chromatography.

The replacement of metals and/or glass with polymers in food contact materials has several potential benefits including lower material cost, corrosion resistance, chemical resistance, reduced weight, finish quality, and durability.

In order to ensure the safety of the consumer, certain regulations are put in place by the FDA to evaluate and control any potential for transfer of chemicals from these polymers to the food itself before approving them for commercial use.

[1] https://www.plasticseurope.org/en/focus-areas/health-and-safety/food-contact

Gel permeation chromatography (GPC), an analytical technique for the determination of the molecular weight distribution of polymers (**Figure 1**), can be used to study food contact polymers by determining the weight fraction of species below a certain molecular weight that can potentially be toxic. GPC can also be used to determine the rate at which a polymeric material might decompose as part of accelerated aging studies.

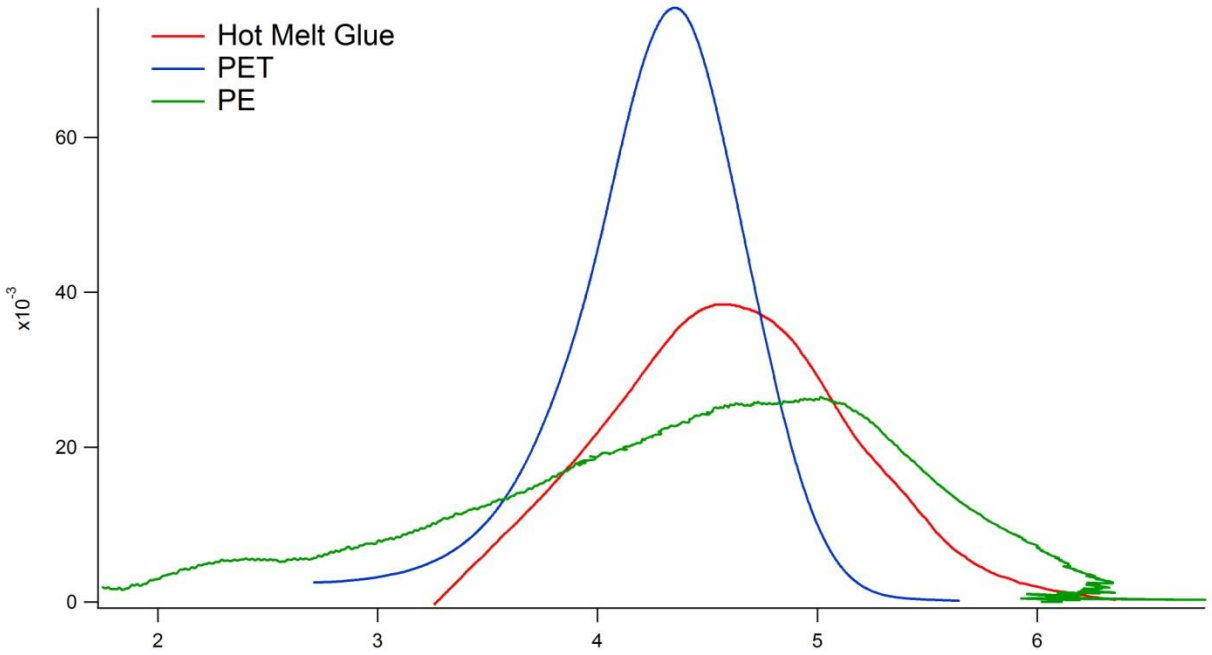

Figure 1. Overlay of food contact polymers in this study

1. Polyethylene

Polyethylene (PE), the most common plastic used commercially, consists of a linear chain of methylene repeat units. PE is obtained upon the polymerization of ethylene in presence of coordination catalysts such as metal chlorides or metal oxides. The most commonly used catalyst is titanium(III) chloride, also called the Ziegler-Natta catalyst. PE can also be obtained by radical polymerization of ethylene.[2]

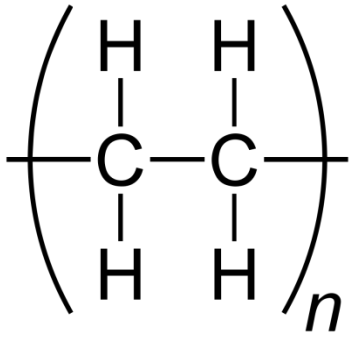

Figure 2. The chemical structure of polyethylene

Depending on the degree of branching, crystallinity, and molecular weight, polyethylene can be be classified into different types such as ultra-high molecular weight PE (UHMWPE), high density PE (HDPE), low density PE (LDPE) and more, and thus offers a wide variety of mechanical properties.

In 2017, over 100 million tons of polyethyelene resins were produced annually, which consisted of 34% of the whole plastics market at the time.[3] Polyethylene is used in almost all types of polymeric materials. In food contact materials, PE is mainly found in packaging materials such as water bottles, plastic bags, trays, jerry cans, in consumer goods such as ice boxes, toys, utensils, in fibers and textiles such as wiring and cables, pipes, steel pipe coatings, and plenty more.

Sample Preparation

A PE sample was dissolved in 1,2,4-trichlorobenzene (TCB) with 0.5 mg/mL butylated hydroxyltoluene (BHT) at 160 ˚C for 60 minutes, yielding a transparent solution. The sample was then analyzed using a **Jordi Resolve Mixed Bed 13 µm** column without further preparation.

[2] https://onlinelibrary.wiley.com/doi/abs/10.1002/14356007.a21_487
[3] http://advances.sciencemag.org/content/3/7/e1700782

Results

The calculated molecular weight averages (M_n, M_w, M_z) and dispersity values (PDI) are presented in **Table 1**. The resulting weight fraction below 1 kDa is also presented in **Table 1**. The refractive index chromatogram is presented in **Figure 3**.

Table 1

Actual Mw Unknown

Polymer	M_n (Da)	M_w(Da)	M_z (Da)	PDI	Weight % < 1000 Da
Polyethylene (GPC-T)	4,584	64,460	431,512	14.060	5.682

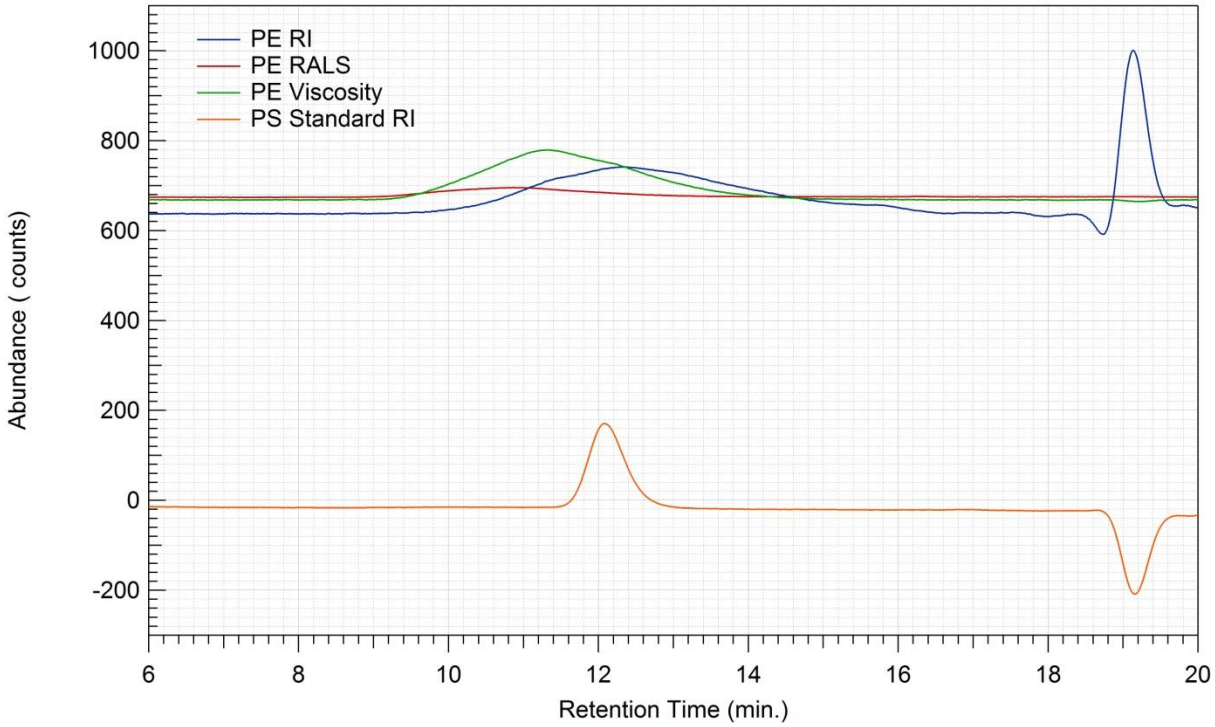

Figure 3. Refractive index (RI) chromatogram of polyethylene

2. Hot Melt Glue

Hot melt glue is a thermoplastic adhesive polymer, which is a solid at room temperature and becomes activated upon heating above its melting point and applied. Upon solidification, hot melt glue retains its new shape and functions as an adhesive.[4] There are several types of polymers that are used as hot melt adhesives including ethylene vinyl acetate, ethylene acrylate, various types polyamides and polyethylenes. Herein, we analyzed ethylene vinyl acetate hot melt glue by GPC.

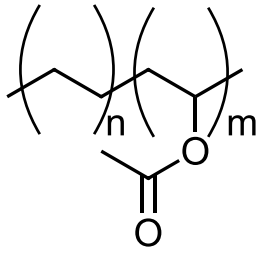

Figure 4. Chemical structure of hot melt glue (Ethylene vinyl acetate)

Hot melt glue finds application in the packaging industry where it is used in the production of paperboard cartons, cardboards, and corrugated boxes. Aside from the packaging industry, hot melt glue is also used in the printing industry, in the shoe industry, in the automotive industry and others.

Sample Preparation

A hot melt glue sample was dissolved in 1,2,4-trichlorobenzene (TCB) with 0.5 mg/mL butylated hydroxyltoluene (BHT) at 160 ˚C for 60 minutes, yielding a transparent solution. The sample was then analyzed using a **Jordi Resolve Mixed Bed 13 µm** column without further preparation.

Results

The calculated molecular weight averages (M_n, M_w, M_z) and dispersity values (PDI) are presented in **Table 2**. The resulting weight fraction below 1 kDa is also presented in **Table 2**. The refractive index chromatogram is presented in **Figure 5**.

Hot Melt Glue
Table 2

Actual Mw Unknown

Polymer	M_n (Da)	M_w(Da)	M_z (Da)	PDI	Weight % < 1000 Da
Hot Melt Glue (Relative to PS)	21,777	90,893	355,048	4.17	N.D.

[4] https://www.adhesives.org/adhesives-sealants/adhesives-sealants-overview/adhesive-technologies/physically-hardening/hot-melt

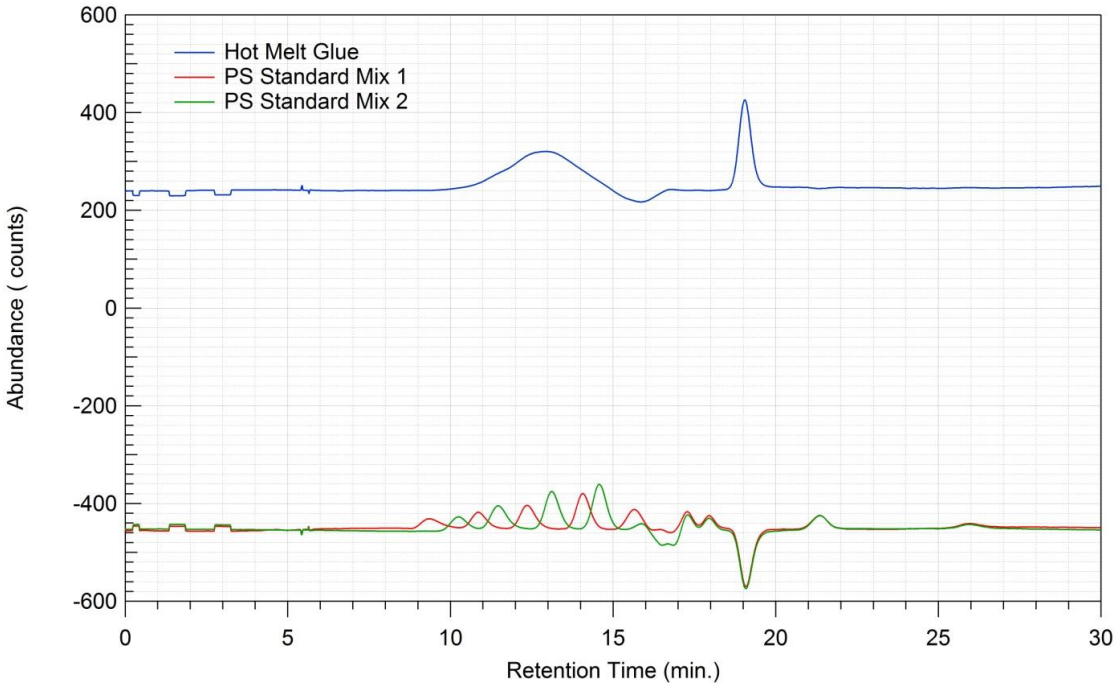

Figure 5. Refractive index (RI) chromatogram of hot melt glue

3. Polyethylene Terephthalate

Polyethylene terephthalate (PET), the most common thermoplastic polyester used commercially, consists of a linear chain of ethylene terephthalate repeat units. PET is available via either a transesterification reaction between ethylene glycol and dimethyl terephthalate or an esterification reaction between ethylene glycol and terephthalic acid.

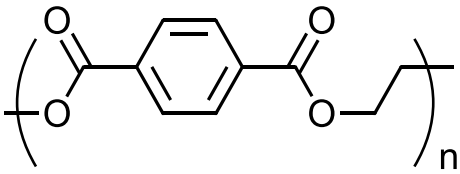

Figure 6. Chemical structure of PET

In its natural state, PET is a colorless, semi-crystalline solid. Since its first commercial production by DuPont, PET technology has evolved to such a level that PET is found in almost every application in our everyday life.[5] PET is one of the most recycled polymers, and possesses several properties such as low gas permeability, transparency, higher strength and stiffness, and more that allows it to be used in several types of domains.[6]

PET is mainly used in the production of plastic bottles for soft drinks, flexible food packaging, several types of blister packs. Crystalline PET is used for both thermally insulated food containers and frozen dinner trays as it can withstand both freezing and oven/microwave hot temperatures.

Sample Preparation
A PET sample was dissolved in HFIP with 0.01 M NaTFA yielding a transparent solution. The sample was then analyzed using a **Jordi Resolve Xstream Mixed Bed** column without further preparation.

Results
The calculated molecular weight averages (M_n, M_w, M_z) and dispersity values (PDI) are presented in **Table 3**. The resulting weight fraction below 1 kDa is also presented in **Table 3**. The refractive index chromatogram is presented in **Figure 7**.

[5] https://www.sciencedirect.com/topics/materials-science/polyethylene-terephthalate
[6] https://omnexus.specialchem.com/selection-guide/polyethylene-terephthalate-pet-plastic

PET
Table 3

Actual Mw Unknown

Polymer	M_n (Da)	M_w(Da)	M_z (Da)	PDI	Weight % < 1000 Da
PET (Relative to PMMA)	10,204	24,889	46,843	2.44	0.90

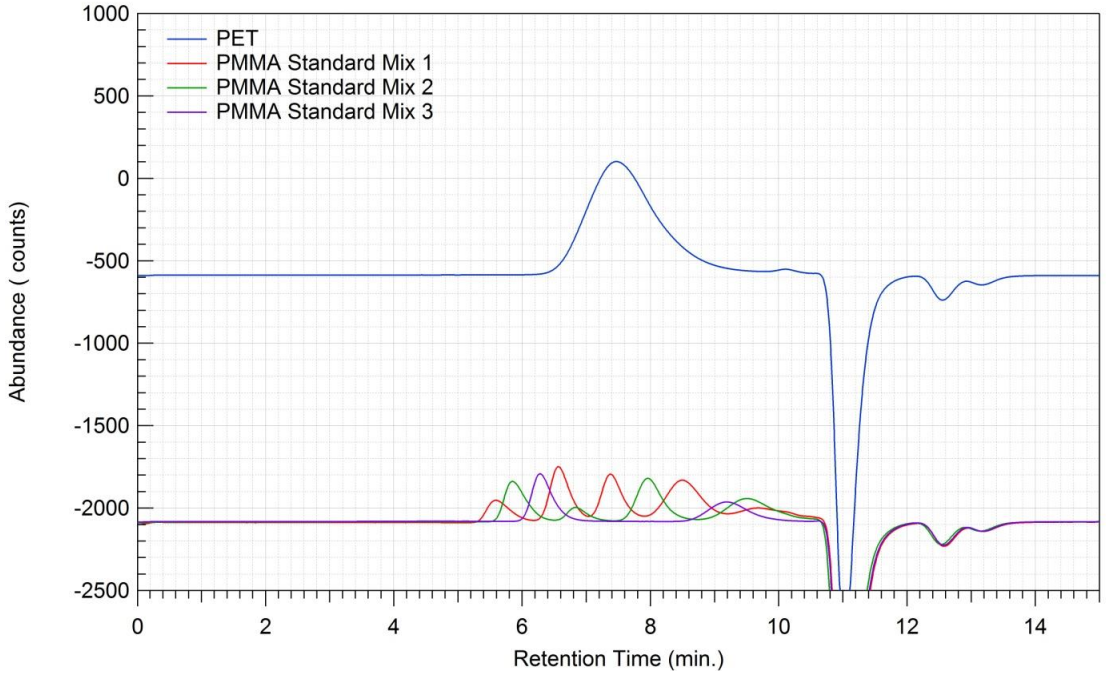

Figure 7. Refractive index (RI) chromatogram of polyethylene terephthalate

Closing Comments

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Jordi Labs specializes in polymer analysis and has more than 35 years' experience performing regulatory, quality control and failure testing. We are one of the few labs in the United States specialized in this type of testing. We will work closely with you to help explain your test results and complete your project goals. We appreciate your business and are looking forward to speaking with you concerning these results.

Sincerely,

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