ANALYSIS OF THE IMPACT OF THE MINISTRY OF ENVIRONMENT BAN ON THE IMPORTATION OF RECYCLED PLASTIC RESIN

FINAL REPORT

July 17, 2009

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AUTHOR: THEODORE SIEGLER / DAI
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INTRODUCTION

The plastic recycling and manufacturing industry in Jordan is an important component of the manufacturing sector in Jordan, providing environmental benefits, as well as job creation through the manufacture of plastic products for use, both within Jordan as well as for export.

During a previous short-term assignment to SABEQ, the author worked with the plastic recycling industry to improve management practices to help insure that this sector would continue to grow as an important component of Jordanôs private recycling and manufacturing sector. At the time of that assignment, interviews with plastic manufacturers who relied on recycled resin expressed significant concerns over a ban on the import of recycled resin from outside of Jordan.

Subsequent to that assignment, the Ministry of Environment proposed a new ban on the use of retail plastic bags in Jordan. SABEQ requested that the author return to Jordan to assist with a determination of the impact that such a ban would have on the plastic industry in Jordan. In conjunction with the analysis of the impact of a proposed ban on the use of retail plastic bags the author was asked to conduct additional research on the continued impact of the on-going ban on the importation of recycled plastic resin on the plastic manufacturing sector.

This draft report addresses this second objective ï an analysis of the continuing impact of the ban on the importation of recycled plastic resin on the plastic manufacturing sector. A separate report will be submitted on the proposed ban on the use of retail plastic bags.

BACKGROUND

The plastic manufacturing sector in Jordan is a dynamic industry producing plastic products for sale in Jordan as well as for export. The Jordanian plastic industry ranges from large firms with multiple plants in the region: such as Adritec, producing state-of-the art drip irrigation piping; Agricultural Plastic Industrial Company producing high quality agricultural mulch and greenhouse films, and pioneering recycling of dirty mulch films; to firms such as Nizam Al-Baradi & Partners Co., manufacturing retail plastic bags for sale in Jordan as well as for export as far away as Dayton, Ohio, USA.

There are also many smaller, family owned plastic manufacturers producing a full range of plastic products for sale in Jordan. These include Awni Abu Saôad Plastic Factory and Orient Plastic Company, both of whom have been in business for more than thirty years, and involving multiple generations of the family, pioneering sophisticated plastic production technologies to produce a range of plastic packages and products.

One thing that all of the plastic manufacturers in Jordan have in common is the need to import virgin plastic resins from surrounding countries because Jordan does not have oil or natural gas reserves, even though it is surrounded by countries with some of the largest reserves in the world. Consequently, the Jordanian plastic manufacturers must rely on the competence of its work force, and their technological expertise to compete against companies in surrounding countries with a competitive advantage in terms of raw material input.

Over the past twenty years Jordan has attempted to grow the economy by exporting manufactured goods. Relatively high tariff and non-tariff barriers for products produced by Jordan manufacturers protected Jordanian manufacturers from lower cost imports, while Jordan ensured these same manufacturers access to cheaper imported capital goods, raw materials, and intermediate goods.[1]

These tariff and non-tariff import barriers on finished goods made it easier for Jordanian plastics companies to complete for the Jordanian market as well as increase exports. However, more recently, as Jordan has moved to reduce trade barriers, it is now easier for companies in Saudi Arabia, especially, to import manufactured plastic products to Jordan and compete directly with Jordanian manufacturers because of the lower resin cost.[2] This is an especially critical problem for plastic manufacturers where material input (resin) costs often represent 70 percent of total production costs.

For this reason, as detailed below, the ban on the import of recycled resins to Jordan has serious negative consequences for plastic manufacturers in Jordan. This paper presents the results of the authorôs research on this issue, both in Jordan (May 17 ï 29, 2009), as well as in the United States. During the time spent in Jordan the author:

- Conducted site visits to eight plastic manufacturing facilities;
- Met with the Managing Director of a plastics trading company;
- Met with the Ministers of Environment and Labor and Industry;
- Held two meetings with the Royal Scientific Society; and,
- Met with representatives of the Jordan Upgrading and Modernization Program.

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[1] Excerpted from the Federal Research Division, Library of Congress, Country Studies, December 1989

[2] In addition, plastic manufacturers in Saudi Arabia do not have to pay customs on the import of goods to Jordan.

Upon returning to the United States, the author interviewed the Director of the Association of Post-Consumer Plastic Recyclers, as well as the Director Environment & Water Resources Europe for Coca-Cola GmbH, and conducted extensive research on Basel Convention issues, and activities in other countries concerning the importation of recycled resins. This report presents the author's findings, conclusions and recommendations.

RESIN DEMAND IN JORDAN

The author has not been able to find accurate data on total resin use in Jordan. However, research by SABEQ, confirmed by the author during discussions with plastic manufacturers and plastic resin trading companies, indicates that Jordan imports roughly 120,000 tonnes of virgin plastic resin per year, primarily from Saudi Arabia, but with significant quantities from as far away as South Korea. In addition, Jordan plastic manufacturers also purchase significant quantities of recycled plastic resin from Jordanian plastic recyclers.

As reported in the author's September 2008 report, there are no data on how much plastic is recycled in Jordan. However, a rough estimate can be made as to the demand for recycled resin from Jordanian plastic manufacturers (note that Jordanian plastic recyclers/reclaimers can sell recycled resin in Jordan and export recycled resin as well).

Pipe manufacturers, especially, as well as furniture manufacturers, can use as much as 50 to 70 percent recycled resin in their products. Film manufacturers can typically use less recycled resin, averaging an estimated 15 – 30 percent for retail bags and 30 – 50 percent for garbage bags.

However, food and pharmaceutical packaging producers, as well as many retail bag manufacturers use no recycled resin. In fact, the majority of plastic bag and packaging manufacturers that the author visited in Jordan did not use recycled resin, or only used their own regrind.

Given the uncertainty about the demand and supply of recycled resin in Jordan, a rough estimate is that total *current* demand for recycled resin in Jordan ranges from 15 to 30 percent of virgin resin use (or 18,000 – 36,000 tonnes per year). However, *potential demand*, assuming access to low cost, high quality recycled resin, could be as high as 60,000 tonnes per year.

CURRENT ECONOMIC IMPACT OF PLASTIC MANUFACTURING IN JORDAN

According to the Jordan Chamber of Industry, there are 330 plastic manufacturers in Jordan.[3] Based on per employee resin consumption data provided to the author during interviews with plastic manufacturers, these plastic manufacturers employ between 3,000 and 4,000 people in the production and sale of plastic products. Assuming an average wage of 350 JD per month, plastic manufacturing generates roughly 13.5 to 16.5 million JD in annual direct wages per year and another 3.4 to 4.1 million JD in social benefits.

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[3] Eng. Anas A. Khasawneh, Officer, Industrial Affairs Department, Jordan Chamber of Industry, based on 2008 registrations.

Data are not available on the indirect and induced jobs generated from direct employment in the plastic manufacturing sector. Based on recent input/output models of the impact of plastic manufacturing in the northeastern United States, which the author helped develop, multipliers might range from 0.75 to 1.1. This would mean that another 2,500 to 4,400 indirect and induced jobs rely on the direct employment in plastic manufacturing, resulting in a total employment impact ranging from 5,500 to 8,400 jobs associated with the production of plastic products in Jordan.

ECONOMIC IMPACT OF THE BAN ON IMPORT OF RECYCLED RESIN

At current prices for PE resin (the largest single resin used/imported in Jordan) of roughly 915 JD per tonne, plastic manufacturers purchase roughly 110 million JD of virgin resin per year. Assuming that Jordanian plastic manufacturers use an additional 18,000 to 36,000 tonnes of recycled resin, at 690 JD, these same manufacturers purchase between 12.5 million and 24.8 million JD of recycled resin from Jordanian plastic recyclers.[4]

The ban on the import of recycled resin in essence acts in the same way as a tariff on the import of recycled resin does, in that Jordanian plastic recyclers/reclaimers do not have to compete on a price or quality basis with imported recycled resin suppliers. This allows plastic reclaimers in Jordan to charge a premium price for recycled resin and/or to sell lower quality recycled plastic resin then they would if they had to compete.

According to one of the largest plastic pipe manufacturers, at the time the ban on the import of recycled plastic resin was implemented, Jordanian plastic reclaimers were selling recycled resin for about one-half of the cost of virgin resin. This is consistent with the current spread between virgin and recycled resin prices for PE in the United States.[5]

In May 2009, it was reported to the author that the difference between imported virgin resin and recycled resin purchased from Jordanian reclaimers is currently roughly 25 percent.[6]

This means that plastic reclaimers in Jordan are currently able to price their recycled resin 25 percent points above market prices. While this is undoubtedly good for plastic recyclers/reclaimers in Jordan, the subsidy is in essence paid by plastic manufacturers in Jordan, placing them at a competitive disadvantage for export, and when competing in Jordan with imported plastic products. The subsidy is also paid by Jordanian consumers who purchase products made from recycled plastic.

An estimate of the subsidy can be made based on current demand for recycled plastic resin. Assuming current demand for recycled resin is 15 percent of virgin use, or 18,000 tonnes per year, Jordanian plastic manufacturers are currently paying roughly 4.1 million JD more for recycled resin then they should be. If the demand for recycled resin is 30 percent of the

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[4] Data are not readily available on the consumption of the major grades of plastic in Jordan. It is likely that PE is the single larges resin type, representing at least 60 percent of total plastic resin consumption.

[5] Plastic News, June 22, 2009, comparison of virgin, extrusion grade LDPE film and Post Consumer recycled resin LDPE film pellets.

[6] Meeting with Mr. Tarek H. Zuobi, Chief Executive Officer, Adritec Group International, May 27, 2009.

demand for virgin resin, then Jordanian plastic manufacturers are paying 8.3 million JD more for recycled resin then they should be.

Part of this subsidy is absorbed by the manufacturers, making them less competitive against imported plastic products. And part of the subsidy is passed on to Jordanian consumers in the form of higher prices for plastic products. The impact of this ban/subsidy is two fold.

First, the higher price for recycled resin means that Jordanian plastic manufacturers produce less plastic product then they would if they had lower costs. It is not unreasonable to assume that the ban on the import of recycled resin, and the resulting higher price for material inputs, has reduced plastic manufacturing output in Jordan by 10 to 20 percent. If that is the case, then the ban is costing Jordan roughly 1,000 (rounded) direct and indirect jobs based on the ratio of plastic resin consumption to total employment in plastic manufacturing in Jordan.

Second, the ban on imported recycled resin forces some plastic manufacturers to use much less recycled resin than they would if they could purchase sufficient quantity and quality of recycled resin. For example, Adritec has developed a process for co-extruding plastic irrigation pipe that can use up to 80 percent recycled resin. However, because of the lack of sufficient high quality recycled resin from Jordanian plastic reclaimers, Adritec reports that they use no more than 30 percent recycled resin. Assuming that resin represents 70 percent of total costs to Adritec, the lack of available high quality recycled resin increases Adritec's cost by roughly 30 to 35 percent. This makes it extremely difficult to compete with pipe manufacturers from surrounding countries, both for export, and more recently for sale in Jordan.

RATIONALE FOR THE BAN

The Ministry of Environment (MOE) maintains that the reason for the ban is that imported recycled plastic resin could contain hazardous chemicals that could leach into food if used in retail plastic bags, or be a danger to children if used in toys or furniture. The MOE also maintains that the Basel Convention allows for the ban on the import of recycled resin because of Jordan's inability to adequately test for hazardous constituents in imported resin.

It is the author's professional opinion that both of the MOE's rationales for the ban are incorrect, for the following reasons.

Ban on Importation of Recycled Plastic Resin Does Not Protect Consumers from Potentially Hazardous Materials

There are two reasons why the ban on the import of recycled plastic resins by Jordanian plastic manufacturers does not protect Jordanian consumers from the threat of contamination by recycled resin.

First, plastic product manufacturers from outside of Jordan are not restricted from importing and selling products in Jordan. As governments around the world now know, there are risks associated with the import of Chinese products (see for example the article entitled "*China-made children's products unsafe – state media"* published in the Jordanian Times on May 29-30, 2009). The ban on the import of recycled plastic resin does nothing to reduce this risk.

Second, there is no restriction on Jordanian plastic recyclers grinding Chinese made products and/or agricultural plastics (that might be contaminated with pesticides and herbicides) to sell to Jordanian plastic manufacturers. Thus, for example, an imported Chinese plastic chair containing heavy metals could be recycled in Jordan, with the recycled plastic sold to a Jordanian plastic manufacture for use in a new plastic toy, without the knowledge of the Jordanian plastic toy manufacturer.

The Basel Convention Restricts Jordan from Banning Recycled Plastic Resin

Annex IIIV and Annex IX of the Basel Convention *Clarification and Characterizations of Wastes* lists "*wastes likely to be hazardous under the convention"* (Annex IIIV) and *"wastes not likely to be hazardous under the convention"* (Annex IX). Recycled plastic resins are listed in Annex IX, not in Annex IIIV. Annex IX specifically states: ***"Wastes placed in Annex IX will not be wastes covered by Article 1, paragraph 1(a) of the Basel Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic."***

Jordan is a party to the Basel Convention.[7] Parties to the Basel Convention can not ban the importation of green list wastes (Annex 1X materials are green list materials as interpreted

[7] Jordan signed the Basel Convention Treaty on June 22, 1989 and ratified it on December 6, 2004. See http://www.ban.org/country_status/country_status_chart.html

by the OECD which is responsible for enforcing the Basel Convention) unless they can prove that hazardous wastes (banned wastes) are present. Jordan does not have any proof that green list recycled resins imported to Jordan would be more likely to contain hazardous wastes then recycled resins produced in Jordan.

The American Society of Testing and Materials, International has published a *Standard Guide for Techniques to Separate and Identify Contaminants in Recycled Plastics.* A copy of this Standard is included Appendix 1 to this document.

The Royal Scientific Society (RSS) of Jordan is the logical institution in Jordan to test resins and plastic products for hazardous contaminants using the ASTM International Standard. However, the RSS does not currently have the capacity to conduct these tests.[8] It is the author's opinion, after meeting with the RSS, that it will take a minimum of two years for the RSS to acquire the necessary testing equipment and train existing personnel to properly use the equipment.

Appendix 2 to this report presents the RSS list of equipment, and the estimated cost of this equipment, that the RSS believes would be necessary to begin such a testing protocol.

Once the RSS obtains the necessary equipment and trains RSS technicians in the operation of the equipment, a statistically valid testing protocol would have to be developed. This will require the development and implementation of a random sampling program to test recycled resin from a representative sample of Jordanian plastic reclaimers, and then obtain and sample recycled resins from suppliers outside of Jordan. This means that realistically it will be at least three years before the RSS would be capable of issuing an opinion as to the potential for hazardous contamination of recycled resins, both from Jordan and from imported resins.

However, even if the RSS were to determine that there were potentially hazardous chemicals in the recycled resin (either from Jordan or from imported recycled resins), it would still be necessary to determine if these chemicals were still present in potentially toxic amounts once they were used to manufacture new plastic products. This would require a statistically valid sampling protocol for testing of new plastic products manufactured from recycled resins, followed by a health risk assessment of the potential health risks associated with what ever levels of contaminants were found (if any).

In summary, it is the author's professional opinion that Jordan should move forward with the funding of the RSS request so that the requisite technical capacity becomes available in the future. It will be of significant benefit to Jordan, and to the plastic recycling and manufacturing sectors. However, waiting a minimum of two years, and more realistically three to four years to acquire the equipment and necessary training and then carry out a statistically valid sampling protocol risks the loss of significant plastic manufacturing capacity in Jordan. More importantly, waiting to develop this testing and analytical capacity, does not achieve the MOE objective given the import of plastic products that may contain hazardous chemicals in the interim.

No Other Countries Have a Blanket Ban on the Import of Recycled Resins

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[8] Meeting with Rafat Ahmad, PhD, Director, Industrial Chemistry Centre, May, 2009

An extensive internet search, together with discussions with other experts in plastic recycling has not identified any other countries that currently ban the import of recycled plastic resins. Two countries in Europe, Italy and Spain, have partial bans on the use of imported recycled resin for *food contact packaging only*.[9] The Director of the Association of Post-Consumer Plastic Recycling (APR) in the United States confirmed that no such ban exists in the United States, and that he is not aware of any restrictions on the export of recycled plastic resins from United States plastics reclaimers.[10]

RISKS ASSOCIATED WITH CONTINUING THE BAN

Plant Closures

The greatest risk to Jordan is the loss of large irrigation pipe and agricultural mulch film manufacturers over the next several years if the ban remains in place. These firms are international firms, they require high quantities of recycled resin, and they can move their equipment at relatively low cost if purchased resin costs make them uncompetitive in the world market.

This is especially the case for Adritec, which is capable of co-extruding drip irrigation pipe with recycled resin sandwiched between two layers of virgin resin. Co-extrusion of recycled resin inside of virgin resin was the earliest way to obtain a ñLetter of No Objectionò from the United States Food and Drug Administration for food contact packaging in the United States. There should be no question about the safety of this process in the production of irrigation pipe in Jordan using recycled resin. At a minimum, the ban should be lifted immediately for co-extrusion for non-food applications.

However, it is the authorõs professional opinion that even without co-extrusion the risks of food contamination associated with the use of recycled resin in drip irrigation pipe is insignificant. As discussed in the previous report to SABEQ, and repeated here, drip irrigation pipe is typically made with a mix of virgin and recycled resin, diluting the potential contaminant ï assuming that one exists after washing, grinding and extruding to produce a pellet, then re-extruding to produce the plastic pipe. The pipe used in drip irrigation piping in Jordan is PE, which is relatively inert ï that is why PE is used for landfill liners because it does not react to hazardous chemicals. This significantly reduces the potential for migration of a contaminant in the PE pipe. However, if migration of the contaminant occurs, it must be carried by the water to the soil, where it must be taken up by the root and transported to the edible portion of the vegetable (except for root crops where one less link in the transport pathway is necessary). At each step of this exposure pathway the risk is reduced, to the point where it is highly unlikely that a risk assessment would find an issue of concern. In fact, the real risk is much more likely to be the direct application of pesticides and herbicides to fruits and vegetables as part of the growing cycle, then the potential for migration from drip irrigation piping.

Reduced Jordanian Employment and Wages

[9] Meeting with Dr. Klaus Peter Stadler, Director Environment & Water Resources Europe, and Director Commercialization & Stewardship Germany, Coca-Cola GmbH, Berlin Germany, July 8, 2009.

[10] Telephone conversation with Steve Alexander, Director, APR, Washington, DC, June, 2009.

Even if Jordanian plastic manufacturers do not move their manufacturing facilities to other countries, the number of jobs for Jordanians is significantly reduced by the inability of Jordanian plastic manufacturers to obtain sufficient quantity and quality of recycled plastic resin. As discussed at the beginning of this report it is likely that at least 1000 plastic manufacturing jobs are lost in Jordan each year that the ban remains in place. This is equivalent to 5 million JD in wages and benefits annually.

The Ban May Increase the Risk of Contamination

There is a real risk that the ban on the import of recycled resins *increases* the risk of contamination of recycled resins produced in Jordan as plastic reclaimers search for new sources of plastic (including agricultural plastics and discarded plastic items manufactured in China) that may contain hazardous constituents.

The Ban Reduces Investment in New Manufacturing Capacity in Jordan

The inability to import recycled resins, together with the artificially high price for recycled resins in Jordan due to the ban reduces potential domestic and foreign investment in new plastic manufacturing capacity in Jordan. This further depresses employment as well as wages and tax revenues. It also plays a role in existing Jordanian company decisions with respect to where to locate another plant. This is especially critical given reported lower costs in Saudi Arabia.

CONCLUSION AND RECOMMENDATIONS

CONCLUSIONS

- There are 330 Jordanian plastic manufacturers in Jordan.
- These Jordanian plastic manufacturers employ an estimated 3,000 to 4,000 workers, with an estimated additional 2,200 to 4,400 additional indirect and induced jobs dependent on the plastic manufacturers.
- Total wages and social benefits realized as a result of the Jordanian plastic manufacturers are estimated to be between 17.9 and 20.6 million JD per year.
- The ban increases raw material costs to Jordanian plastic manufacturers by roughly 25 percent, resulting in an additional expenditure of between 4.1 and 8.3 million JD per year.
- The additional cost to purchase recycled resin results in an estimated loss of 1000 jobs, or 5.25 million JD in lost wages and social benefits.
- The ban does not protect Jordanian citizens because products made from recycled resin can still be imported into Jordan, and because the ban increases the use of more marginal recycled resins from within Jordan.
- The ban is in potential violation of the Basel Convention, which Jordan is a party to, because it bans green list materials (recycled plastic resin) without proof of contamination.
- The Consultant is not aware of any other countries in the world that ban the import of recycled plastic resin for non-food packaging applications.
- Jordan does not have the capacity to test for contamination of resins, either imported or domestic to prove that recycled resin from outside of Jordan is inherently more likely to be contaminated than recycled resin from Jordan.
- It will take a minimum of two to four years for the RSS of Jordan to acquire the necessary equipment, train staff, establish a statistically valid sampling protocol, and compile a large enough database to assure the integrity of all recycled plastic resins.
- In the interim, unless the ban is lifted Jordan risks the loss of existing plastic manufacturing capacity to neighboring countries, as well as the loss of an estimated 1000 plastic manufacturing jobs each year associated with reduced production of plastic products in Jordan as a response to artificially high recycled plastic resin prices.

RECOMMENDATIONS

- Jordan should provide RSS with the investment to acquire the necessary testing equipment and train competent staff to operate the equipment.

- Jordan should not wait for the RSS to acquire the necessary equipment and training, and to create a statistically valid sampling protocol, because it will take an estimated two to four years, and the ban will not protect Jordanian citizens in the interim

- The ban on the import of recycled plastic resin should be rescinded as soon as practicable because the ban does not protect Jordanian citizens from the potential for contamination by recycled plastic resin produced in Jordan, and from plastic products produced outside of Jordan and imported to Jordan. Failure to rescind the ban risks the loss of significant plastic manufacturing capacity in Jordan.

- Jordan should step up efforts to assure that food grade packaging is not produced with recycled resin. All of the food grade-packaging producers that the author visited reported that they do not currently use recycled plastic resin, and have no plans to do so.

- Jordan should consider the prohibition of the use of black plastic retail bags as one way to ensure that retail bags containing recycled resin are not used for food.

APPENDIX I

Designation: D 5577 – 94 (Reapproved 2003)

Standard Guide for Techniques to Separate and Identify Contaminants in Recycled Plastics[1]

1. Scope

2. Referenced Documents

2.1 *ASTM Standards:*

2.2 *ISO Standards:*

3. Terminology

4. Summary of Guide

5. Significance and Use

6. Sampling

7. Existing ASTM or ISO Procedures


D 5577 – 94 (2003)

8. Additional Industrial Procedures


9. Report

10. Keywords

APPENDIX

(Nonmandatory Information)

X1. IDENTIFICATION OF CONTAMINANTS ADDRESSED BY SPECIFIC TEST PROCEDURES

APPENDIX II

A Proposal for Upgrading f Plastic Characterization Unit for Testing & Monitory of Plastic Materials & Products in Jordan

Mission and Objectives

The mission of the proposed **Plastics Characterization Unit** is to provide, through technical testing, research and monitory activities, the means ***to ensure that plastic product is safe and meets domestic and foreign regulatory requirements***. This will help to decrease the hazards of both virgin and recycled products. Moreover, by enforcing measures for the testing of plastic products, the ***consumers will be protected***, and consequently, the ***growth of Jordan's plastics industry will be promoted***.

Output

Once established at the Royal Scientific Society (RSS), the Plastics Characterization Unit will be an example of a leading entity that will be a natural evolution of RSS continuous development.

This unit will offer a comprehensive range of state-of-the-art mechanical, thermal, and chemical Analysis tech niques.

Introduction

There is a significant increasing need for the plastics industry to meet the challenge in reducing the amount of solid waste disposals by resorting to the use of recycled materials in the fabrication of products. However, **due to the permeable nature of plastics, the possibility that chemical contaminants resulting from post-consumer misuse** (automotive fuels and oils, solvents, pesticides, toxic organic salts involving heavy metals, antifreeze, household cleaners, etc.) **remain in the recycled plastics and migrate into food**, for example, which is one of the major concerns regarding the safety of recycled plastics used in food packaging applications, and other applications i.e. medical, textiles, etc.

Therefore, manufacturers of virgin/recycled plastic materials made for human-direct-use **must test the physical and chemical properties of virgin/recycled plastics in the same manner as virgin materials, to ensure that the plastic products are** of suitable purity for their intended use and will meet all existing specifications for the **virgin plastics, and meet the technical requirements for their functional purposes.**

RSS applies multiple techniques, such as spectroscopy, chromatography and microscopy to examine the components of plastic and polymer products.

The materials identification services to the plastics industry will include physical testing and chemical analysis as follows:

- Contaminant identification
- Additive analysis
- Quality issues (virgin or recycled polymer)
- Base polymer identification
- Average molecular weight and distribution

Overview of Testing & Research Components

RSS has three diversified laboratories dealing with chemical and mechanical testing. The Rubber and Plastics Laboratory, the Chromatography Laboratory (organic identification), the Spectroscopy Laboratory (inorganic identification), and Radiation laboratory .These laboratories, combined, have strong technical capabilities and an impressive aggregation of expertise. The staff of these laboratories is committed to achieving the Plastics Characterization Unit goals through working on the following research components:

1. Plastics Physical Characterization and Testing

The physical properties (mechanical and thermal behavior) of polymer are changing after they are processed into final products. Therefore, plastics characterization and testing are needed to distinguish between products that are produced from virgin or already recycled (post-consumer) plastics.

The Rubber and Plastics Laboratory at MDTC offers valuable consultancy and testing services for the identification, characterization and evaluation of polymeric materials and products. It also offers on-site supervision on locally produced plastic items for key projects in Jordan. The technical competence of the Plastic and Rubber Laboratory is recognized nationally and internationally. It is the first testing laboratory in Jordan to be granted national accreditation.

Our goal is to develop tests that are precise, reliable, and rapid enough to detect if the plastic product/ materials are made from virgin/or/recycled raw polymer prior to their admittance to the market.

2. Chemical Contamination & Residue

The possibility that chemical contaminants in plastic materials intended for recycling may remain in the recycled material and could migrate into the surrounding the material contacts is one of the major considerations for the safe use of recycled plastics for human-contact applications.

Serious consequences have been reported when plastic products contaminated with pesticides or, toxic organic salts involving heavy metals, such as lead, cadmium, or mercury; have been utilized by people. Effective detection of chemical residues in food can greatly reduce the risks of causing health problems. Thus, both organic and inorganic analyses need to be enhanced at ICC to be able to cover the type of analyses required.

> **ICC** is staffed with experienced technologists and scientists who are working with a variety of analytical instruments to determine chemical constituents in a range of sample matrices. **The Organic Chemistry Division** applies sophisticated technologies to the surveillance of chemical residues in different products using GC/MS units. RSS has an extensive track record of providing analytical and consultancy services to the "National Committee for Studying the Impact of Pesticides on the Environment". **The Pesticides Residue Laboratory** is equipped with Gas Chromatographs linked to Mass Spectrometers (GC-MS) for the routine analysis of pesticides (organochlorines). **The Inorganic Chemistry Division** performs determination of heavy metals, such as lead, mercury, cadmium, copper, iron, zinc, or major ions, such as sodium and calcium.

The major goal is to develop reliable, effective, accurate, user-friendly, and cost-effective residue detection methodology that requires minimal amounts of organic solvents to detect these residues in plastic products prior their admittance to the local market.

Requirements

The effectiveness of this unit is largely dependent on the available resources, the available equipment, technical capability and capacity, knowledge, skills and abilities of the staff, and access to technically up-to-date information and methods.

Upgrading and modernization of RSS's Plastic Characterization Unit will involve:

- **Upgrading Laboratory Equipments**

The required equipments are:

1) Thermogravimetric analysis (tga) or thermal gravimetric analysis (more specifications are provided in the appendix).
2) Differential scanning calorimetry (dsc) (more specifications are provided in the appendix).
3) Thermo-mechanical analysis (more specifications are provided in the appendix)
4) Cutter machine for sample preparation for testing machine
5) Twin-extruder system and injection molding (lab scale) for sample molding
6) Gc-ms headspace (upgrading)
7) UV-Spectrophotometer (upgrading)
8) SEM/EDXA (new machine)

- **Personnel Skills**

Although the educational background of current staff is generally high, the staff is not familiar with the state-of-the-art analytical equipment and analytical methods. Therefore, ***we believe specialized training is required to raise the performance of existing and new staff to a professional level.***

Budget

The total estimated budget to establish this unit at RSS is 200,000 JD (Two hundred thousands JD). In addition to the advanced instrument which should be available as well, which is SEM/ EDXA and its cost is 270,000 JD (Two hundred and seventy thousands JD).

The budget is distributed as follows:

	Machine	**New/ or Upgrading**	**Cost [JD]**
1	Differential Scanning Calorimetry DSC	New	30 000
2	Thermogravimetric Analysis TGA	New	15 000
3	Thermo-mechanical Analysis TMA/ DMTS	New	30 000
4	Cutter machine for sample preparation	New	5 000
5	Twin-extruder system and injection molding (lab scale)	New	25 000
6	Gel Permeation Chromatography GPC	New	30 000
7	GC-MS headspace	upgrading	15 000
8	UV-Spectrophotometer/ configuration for plastics	upgrading	15 000
9	Spare parts and consumables	--	25 000
10	Training	--	10 000

	Advanced Instrument	**New/ or Upgrading**	**Cost [JD]**
1	SEM/ EDXA (advanced instrument)	New	270 000

Expected Outcome and Benefits

1. Novel tools will be developed and evaluated as potential standard tools in support of health, environment, and safety policy making in Jordan.
2. The upgraded laboratory will be a sound technical arm for the government in terms of applying national and international plastics specifications, and providing expert opinion and consultations.
3. The upgraded laboratory will perform third-party verification tasks for quality control/assurance of plastics testing.
4. Jordan's policy makers and plastic sectors will negotiate existing and forthcoming plastic product safety issues based on strong and scientifically sound evidence.
5. Identification of emerging plastics hazards and contaminants.
6. No hazardous plastic waste and minimal chemical residues in plastic products reaching the consumer.
7. Plastics Characterization Central Unit will be accessible and beneficial to the scientific community.

Today's investments in plastics characterization research and monitoring will result in tomorrow's savings in health-care and industry costs. Knowledge generated in this area will push Jordan to compete on the international scale.

APPENDIX III

1) The Thermogravimetric Analysis (TGA) Technique

- TGA measures the amount of weight change of a material, either as a function of increasing temperature, or isothermally as a function of time, in an atmosphere of nitrogen, helium, air, other gas, or in vacuum.
- Inorganic materials, metals, polymers and plastics, ceramics, glasses, and composite materials can be analyzed.
- Temperature range from 25°C to 1000°C routinely. The maximum temperature is 1000°C.
- Sample weight 1 g including tare.
- Weight change sensitivity of 0.001 mg.
- Samples can be analyzed in the form of powder or small pieces so the interior sample temperature remains close to the measured gas temperature.

Applications of Thermogravimetry

- Determines temperature and weight change of decomposition reactions, which often allows quantitative composition analysis. May be used to determine water content.
- Allows analysis of reactions with air, oxygen, or other reactive gases (see illustration below).
- Can be used to measure evaporation rates, such as to measure the volatile emissions of liquid mixtures.
- Allows determination of Curie temperatures of magnetic transitions by measuring the temperature at which the force exerted by a nearby magnet disappears on heating or reappears on cooling.
- Helps to identify plastics and organic materials by measuring the temperature of bond scissions in inert atmospheres or of oxidation in air or oxygen.
- Used to measure the weight of fiberglass and inorganic fill materials in plastics, laminates, paints, primers, and composite materials by burning off the polymer resin. The fill material can then be identified by XPS and/or microscopy. The fill material may be carbon black, TiO_2, $CaCO_3$, $MgCO_3$, Al_2O_3, $Al(OH)_3$, $Mg(OH)_2$, talc, Kaolin clay, or silica, for instance.
- Can measure the fill materials added to some foods, such as silica gels and titanium dioxide.
- Can determine the purity of a mineral, inorganic compound, or organic material.
- Distinguishes different mineral compositions from broad mineral types, such as borax, boric acid, and silica gels.

ASTM Test Methods Using Thermogravimetric Analysis

- ASTM D2584 - Standard Test Method for Ignition Loss of Cured Reinforced Resins
- ASTM E1131 - Standard Test Method for Compositional Analysis by Thermogravimetry

2) The Differential Scanning Calorimetry (DSC) Technique

- DSC is used to measure melting temperature, heat of fusion, reaction energy and temperature, glass transition temperature, phase transition temperature and energy, and specific heat or heat capacity.
- DSC measures the amount of energy absorbed or released by a sample when it is heated or cooled, providing quantitative and qualitative data on endothermic (heat absorption) and exothermic (heat evolution) processes.
- Only non-corrosive samples can be analyzed in this very sensitive instrument. No organic or other materials containing F, Cl, Br, or I may be submitted for DSC analysis. The customer must either tell us what the material is or at least that it is non-corrosive and assume responsibility for possible replacement of a $3000 DSC cell if a cell is destroyed as a result of the analysis of their sample. Or, you may have us perform such analysis as may be needed to determine what the material is and whether it can be analyzed in the DSC.
- Number of samples: 24 samples per tray.
- The sample is placed in a suitable pan and sits upon a constantan disc on a platform in the DSC cell with a chromel wafer immediately underneath. A chromel-alumel thermocouple under the constantan disc measures the sample temperature. An empty reference pan sits on a symmetric platform with its own underlying chromel wafer and chromel-alumel thermocouple. Heat flow is measured by comparing the difference in temperature across the sample and the reference chromel wafers.
- Temperature can range from -140°C to 600°C, though an inert atmosphere is required above 600°C. The temperature is measured with a repeatability of ±0.1°C.
- Pans of Al, Cu, Au, Pt, and graphite are available and need to be chosen to avoid reactions with samples.
- Atmospheres: nitrogen, air, oxygen, argon, vacuum, controlled mixed gases.
- Sample size: from 0.5mg to 100mg.
- Used to determine the thermal properties of plastics, adhesives, sealants, metal alloys, pharmaceutical materials, waxes, foods, lubricants, oils, catalysts, and fertilizers

Applications of Differential Scanning Calorimetry

- Metal alloy melting temperatures and heat of fusion.
- Metal magnetic or structure transition temperatures and heat of transformation.
- Intermetallic phase formation temperatures and exothermal energies.
- Oxidation temperature and oxidation energy.
- Exothermal energy of polymer cure (as in epoxy adhesives), allows determination of the degree and rate of cure.
- Determine the melting behavior of complex organic materials, both temperatures and enthalpies of melting. can be used to determine purity of a material.
- Measurement of plastic or glassy material glass transition temperatures or softening temperatures.
- Determines crystalline to amorphous transition temperatures in polymers and plastics and the energy associated with the transition.
- Crystallization and melting temperatures and phase transition energies for inorganic compounds.
- Oxidative induction period of an oil or fat.
- May be used as one of multiple techniques to identify an unknown material or by itself to confirm that it is the expected material.
- Determine the thermal stability of a material.
- Determine the reaction kinetics of a material.

- DSC can also be used to measure glass transition temperatures, melting temperatures, crystalline phase formation temperatures, and crystalline to amorphous transition temperatures.

ASTM Test Methods

- ASTM E793 - Standard Test Method for Enthalpies of Fusion and Crystallization by DSC
- ASTM E794 - Standard Test Method for Melting and Crystallization by DSC
- ASTM E928 - Standard Test Method for Determination of Purity by DSC
- ASTM E1356 - Standard Test Method for Glass Transition Temperatures by DSC

3) Thermo-mechanical Analysis (TMA) Technique

The TMA uses interchangeable probes at varied loads to make a number of measurements, including the softening temperature or glass transition temperature, tensile modulus, compression modulus, coefficient of thermal expansion (CTE), melting temperature, crystalline phase transition temperature, crystalline to amorphous transition temperatures, and creep under load, by measuring the change of a dimension of a material. Note that the thermal expansion of a material may not be linear.

- Samples in the form of plugs, films, powders, or fibers, are compressed or held in tension by a probe assembly.
- Capable of testing polymers and plastics, metals, glasses, inorganics, composite materials, IC packages, semiconductors, small devices, adhesives, sealants, potting compounds, PCBs, and coatings.
- Temperatures can range from -70°C to 320°C.
- Sample dimensions: a maximum of 25 mm in height and 9.5 mm in diameter; a minimum of 0.1 εm thick and 1.5 mm in diameter, an ideal thickness being 1-4mm. Taller samples should have small lateral dimensions, so the sample interior temperature will not differ substantially from the surface temperature.
- The applied load can range from 0-100 g.
- The change of dimension should be greater than $2x10^{-3}$ εm/°C.

ASTM Test Methods

- ASTM E228 - Standard Test Method for Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer
- ASTM E831 - Standard Test Method for Linear Thermal Expansion of Solid Materials by TMA
- ASTM E1545 - Standard Test Method for Assignment of the Glass Transition Temperature by TMA

USAID Jordan Economic Development Program
Salem Center, Sequleyah Street
Al Rabieh, Amman
Phone: +962 6 550 3050
Fax: +962 6 550 3069
Web address: **http://www.sabeq-jordan.org**