Life Cycle Inventory Gate-to-Gate of Metallized Biaxially-Oriented Polypropylene

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Multilaminates

- Important in packaging

- Wide array of
  - Materials
  - Number of layers
  - Weights

Multilaminate Packaging Database

- Objectives
  1. Introduce life cycle technology as a tool for evaluating the broad concept of packaging improvement

  2. Identify the recurring materials and processes that make up 90% of all multilaminate packaging and begin to assemble these as a database

  3. Begin to establish a consortium of users for this life cycle information

Related issues addressed by life cycle information

1) Green purchasing

2) Carbon footprints

3) International labeling or US rating systems

4) Demand for recycle content from consumers

5) Corporate sustainability policies

6) CO_2 (or other emissions) trading credits

7) Challenges of landfill shortages over the long term

8) European and Japanese government initiatives to require full life cycle responsibilities

Multilaminate Packaging

Layers representative of multilaminate sealed pouch for snack food

Layer	Thickness (microns)
printed oPP	17.0
Adhesive, ethylene - vinyl acetate copolymer 93 moleP E,	0.5
polyethylene	48
Adhesive, ethylene - vinyl acetate copolymer 93 moleP E	0.5
Metalized oPP, 125 nm aluminum	12.0
Total	78

Metallization on oriented polypropylene (OPP)

- Aluminum wire

  UIDLiquidAluminum→UIDAluminumwire→Al(s) →Al(l) →Al(g) [+ oPP] → metallized oPP film

- Boat devices (boron nitride-titanium diboride) for melted aluminum to be vaporized

- Reel to reel winding (50,000 m by 3 m wide)

- Vacuum chamber (5 E-07 atm)

Mass Balances

Mass of Aluminum on 50,000 meters long by 3 meters wide roll

50,000 meters long by 3 meters wide (metallization of oPP) roll				
Aluminum thickness	Total OPP output	Aluminum volume	Al	Mass of aluminum
nm	m^2	m^3	kg/m^3	kg
125	1.50E+05	1.74E-03	2700	4.70

4 sources describe the aluminum vaporized that is not on film
(50% - 65% We used 55 wt% as representative

Boats

Aluminum distribution from single boat=16 inches	
sheet width (inches)	number of boats
204	12.75

Loss from boat deterioration

deterioration (lbs)		hr	lbs/hr	kg/hr	BN* kg/boat/hr	B_2Ti* kg/boat/hr
0.500	per	15.0	0.0333	0.0151	7.56E-03	7.56E-03

*50/50 wt% boron nitride /titanium diboride assumed

Energy Balances per 1000 kg oPP metallized

Process Diagram Label	Unit	Energy input [MJ / 1000 kg Product]	Energy Type
Hx1 (Al melt)	Heat exchanger 1	195	E
Hx2 (Al vapor)	Heat exchanger 2	2230	E
vacuum pumps	vacuum pumps	39.6	E
	Potential recovery	0	
	Net energy		
	Electricity	2465	
	DowTherm	0	
	Heating steam	0	
	Direct fuel use	0	
	Heating natural gas	0	
	Diesel process	0	
	Undefined	0	
	Energy input requirement	2465	
	Cooling water	0	
	Cooling refrigeration		
	Potential heat recovery	0	
	Net energy	2465	

2 Sources describe energy use for metalizing as 30%-35% direct and balance as heat loss – already included here

Summary of LCI Information

Inputs					
Input UID	Input Name	Input Flow	Input purity	Units	Comments
UIDBoPP	BoPP	970		[kg/hr]	
UIDAluminumwire	Aluminumwire	54.8		[kg/hr]	
	Total	1025		[kg/hr]	
Non-reacting inputs					
UID	Name	Flow	Purity	Units	Comments
12045-63-5	titanium boride	2.08e-2		[kg/hr]	
10043-11-5	Boron nitride	2.08e-2		[kg/hr]	
	Total	4.15e-2		[kg/hr]	

Basis 1,000 kg/hr of oPP metallized

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Products					
Product UID	Product Name	Product Flow	Purity	Units	Comments
UIDOPP125nmAl	OPP125nmAl	1000		[kg/hr]	125 nm aluminum on 12 micron oPP
	Total	1000		[kg/hr]	

Basis 1,000 kg/hr of oPP metallized

Chemical Emissions						
Emission UID	Emission Name	Gas Flow	Liquid Flow	Solid Flow	Solvent Flow	Units
12045-63-5	titanium boride	0	0	2.08e-2	0	[kg/hr]
10043-11-5	Boron nitride	0	0	2.08e-2	0	[kg/hr]
UIDAluminumwire	Aluminumwire	0	0	24.7	0	[kg/hr]
Totals		0	0	24.7	0	[kg/hr]

Basis 1,000 kg/hr of oPP metallized

Energy use		
Energy type	Amount	Comments
electricity	2465	[MJ/hr]
Net input requirement	2465	[MJ/hr]
Net energy	2465	[MJ/hr]

This is process energy

Using 3.1 MJ fuel/MJ electricity and 1.1 MJ fuel to deliver fuel to electric power plant 2,465 MJ/hr = 8,400 MJ natural resource energy

This is about 500 kg CO_2e/1000 kg oPP metallized

Conclusions

- Demonstrated the use of life cycle inventory (lci)
- Integration of process mass and energy information to obtain representative metallizing lci
- These results can be directly scaled to yield
  - different aluminum levels
  - different metals
  - different films
- The metalized film is one of the examples of the database on multilaminate packaging