INDOFIL INDUSTRIES LIMITED

(Formerly known as Indofil Organic Industries Ltd.)

PVC ADDITIVES

INDOFIL K-120 ND

Processing aid makes the rigid PVC work better

1. INTRODUCTION

Rigid PVC is a versatile plastic having an excellent combination of strength, chemical inertness and fire resistance. It is, however, difficult to fabricate. Its poor hot strength and lack of cohesiveness at processing temperatures prevent it from flowing smoothly through processing machinery. Additionally, calendared and extruded PVC products may exhibit surface imperfections such as air streaks and melt fractures.

Indofil K-120ND processing aid is a highly dispersible power that prevents many problems associated with PVC processing. The excellent dispersibility of Indofil K-120ND processing aid results in fewer gels or fish eyes in clear vinyl formulations. Compounds containing one to five percent of the processing aid fuse rapidly, flow smoothly, have excellent hot strength, and are readily formed. Clarity, rheology, heat stability and crease whitening resistance of PVC modified with Indofil K-120ND processing aid enhances powder flow and achieves molecular weight consistency.

2. PHYSICAL CHARACTERISTICS

The typical properties of Indofil K-120ND processing aid are presented in table 1.

Table 1
Typical Physical Properties
(These do not constitute specifications)

Appearance	White, fine free-flowing powder with uniform particle size
Bulk Density, g/cc	0.40 to 0.44
Specific Gravity, @ 25°C	1.18
Refractive Index, @ 25°C	1.49
Molecular Weight	Medium
Volatiles (%)	Max 0.5
Sieve Test Retention time	
60 Mesh	Max 0.5
100 Mesh	Max 5
200 Mesh	Max 10
Solubility in	Methy ethyl ketone, cyclohexanone, terahydrofuran, toluene, and ethylene dichloride (moderately cloudy solutions which form clear films)
Clarity in 10% toluene solution	Clear
10% Toluene Solution Viscosity (cps)	200-1000

3. PERFORMANCE CHARACTERISTICS

3.1 Fusion and Melt Homogeneity

Indofil K-120ND processing aid promoters rapid fusion of rigid PVC compounds, resulting in highly homogeneous melts. Table 2 compares the fusion time and torque of a PVC compound with and without processing aid; testing was performed in a Brabender Plastic order. The data show that Indofil processing aid substantially reduces fusion time.

Figure 2 illustrates the effect of Indofil K-120ND processing aid on the mill processing characteristics of PVC at 175°C. The photograph on the left shows that unmodified PVC does not form a smooth rolling bank; the material shreds and crumbles, and the small amount of resin which spreads out over the rolls forms a fragile sheet flawed by air streaks and a rough surface. The photograph on the right shows that Indofil K-120ND processing aid produces rapid fusion and promotes the formation of a smooth rolling bank and a strong smooth sheet with well-knit edges.

3.2 Hot Strength and Flow

A unique and fundamental property of Indofil K-120ND processing aid is its ability to improve the hot strength and cohesiveness of PVC. Figure 3 illustrates a simple but reliable test for hot strength in which a milled sheet of PVC is cut and stretched. When unmodified PVC sheet is stretched, it tears crumbles, and loses its integrity. PVC sheet containing Indofil K-120ND processing aid maintains its integrity and forms a strong sheet free of pinholes and surface imperfections Indofil K-120ND processing aid provides benefits in extrusion, below molding, and other fabricating methods used for rigid PVC.

3.3 Plateout

Pigments, lubricants, and other ingredients of low solubility can accumulate on calender rolls, extruder screws, die lips and finishing equipments. The deposits are known as plateout and can cause imperfection in the surface of processed plastic. Eventually equipment must be shut down for tedious and expensive cleaning. Indofil K-120ND processing aid helps eliminate plateout and keeps machinery clean.

In Figure 4, the photograph on the left shows plateout resulting from the processing of unmodified PVC; the photograph on the right shows the same rolls after processing PVC containing Indofil K-120ND processing aid extends the operating period between shutdowns for cleaning.

3.4 Dispersibility

Indofil K-120ND processing aid has excellent dispersibility in the softer vinyl resins and copolymers used for clear packaging, thereby eliminating the fish eyes which reduce the clarity and sparkle of finished products.

Visual observation shows almost complete lack of fish eyes in systems containing Indofil K-120ND processing aid; this is true even of of particularly sensitive systems like milled or blown specimens of low molecular weight PVC (K=55)

3.5 Efficiency and Output Rate

Although the use of a processing aid increases the raw material cost of PVC compounds, Indofil K-120ND processing aid can provide manufacturing economies which compensate for the increase, including higher output rates, reduce overall consumption of material, and greater overall production efficiency. Lower sensitivity to sharing stresses permit extrusion and calendering at high rates. Reduced surging results in extruded products of lower weight and closer conformance to minimum specified dimensions, thereby lowering the overall amount of material used. Control of plateout extends the length of production runs and lowers the frequency of cleanups and unproductive downtime in production lines.

3.6 Effect on Physical Properties of PVC

Table 3 lists the physical properties of milled and molded rigid PVC compounds with and without Indofil K-120ND processing aid. The data shows that normal level of processing aid have practically no effect on the physical properties of PVC. Indofil K-120ND processing aid permits the manufacture of high quality parts over a broad range of shear rates and processing conditions.

Table 4 lists observations of the milling characteristics and clarity of PVC compounds containing zero to five parts of Indofil K-120ND processing aid.

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TABLE 2
EFFECT OF INDOFILL K-120ND PROCESSING AID ON FUSION TIME AND TORQUE

Processing Aid	%	Temperature	Fusion Time,Min	Fusion Torque		Equilibrium Torque	
				Meter-Grams	°C	Meter-Grams	°C
None	0	175	3.25	2300	180	1950	185
Indofil K-120ND	3	175	1.50	3100	165	2200	185

FORMULATION:	**PARTS**
PVC (K=62)	100.00
Processing Aid	0 or 3.00
Tin Stabilizer	2.00
Glyceryl Monostearate	0.75
Montan Ester Wax	0.75

Conditions: Brabender Plastic-Corder No. 6 roller head, 56 g charge, 170°C, 60 rpm

TABLE 3
PHYSICAL PROPERTIES OF PVC COMPOUNDS MODIFIED WITH INDOFIL K-120ND PROCESSING AID

Property	Test Method	Parts of Indofil K-120ND	
		0	3
IZOD Impact Strength	ASTM D 256		
1/8-in.23°C		1.0	0.9
13°C		0.7	0.6
0°C		0.6	0.6
1/4in.23°C		0.9	0.9
Tensile Properties	ASTM D 638		
Elongation of Break, %		188	200
Maximum Strees, psi		7600	7400
Modulus, psi X 10^3		387	384
Flexural Properties	ASTM D 790		
Maximum Strees, psi		13,300	13,800
Modulus, psi X 10^3		447	444
Heat Distortion Properties			
DTUL (264 psi)°C	ASTM D 648	72	73
Vicat temperature, °C	ASTM D 1525	76	75
Rockwell L Hardness	ASTM D 785	77	77

FORMULATION:	**PARTS**
PVC (K=61)	100.0
Indofil K-120ND Processing Aid	0 or 3.0
Tin Stabilizer	2.5
Calcium Stearate	2.0
Polyethylene Wax	0.1
Titanium Dioxide	1.5
Carbon Black	0.2

All tests run on millied and molded slabs.



TABLE 4
Milling Characteristics of PVC Compounds Containing a indofil K-120ND Processing Aid

Parts of Indofil K-120ND	0	5
Milling Properties at 175°C		
Flux Time, seconds	30	30
Rolling Bank	Poor	Excellent
Hot Strength	Poor	Excellent
Thermoplasticity	Poor	Excellent
Clarity		
% White Light Transmission	88.0	83.0
% Haze	4.2	4.8
Static Thermal Stability at 175°C		
Initial colour	Pale Yellow	Pale Yellow
Minutes to Discoloration	20	20
Minutes to Char	40	50

FORMULATION:	**PARTS**
PVC (K=61)	100.00
Indofil K-120ND Processing Aid	0 or 5.00
Tin Stabilizer	2.00
Glyceryl Monostearate	0.75
Monotan Ester Wax	0.75

Thus, the benefits provided to PVC by Indofil K-120 ND processing aid can be summarized as follows:

- Decreased fusion time
- Highly homogeneous melts
- Smooth processing
- Excellent hot strength, cohesion, rolling bank, and well-knit edges
- Smooth, glossy surface free of pinholes, air streaks and melt fractures
- Deep drawing of vaccum-formed and thermoformed parts
- Reduced plateout
- Excellent dispersibility in homopolymers and copolymers
- Increased output rates
- Improved efficiency in extruders calenders
- Integrity of PVC physical properties
- Good pigment loading and thermal stability

4. APPLICATIONS

Indofil K-120ND processing aid can be used for a wide variety of PVC products, including :

- Blown film
- Blown-molded bottles
- Calendered sheet and film
- Extruded sheet and film
- Injection-molded parts
- Pipe and conduit
- Plasticized sheet and film
- Rigid and flexible PVC foam
- Siding, window profiles, and other weatherable products
- Vaccum-formed parts

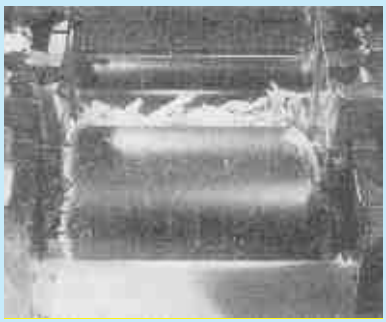
Let us discuss few of them below:

4.1 Calendered Sheet

Using Indofil K-120ND processing aid during calendering operations provides the following advantages:

- Faster fluxing
- Smooth rolling bank, completely knit running edges
- Reduced plateout on processing, embossing, and polishing rolls
- Improved gloss, smooth surfaces
- Improved thermoforming characteristics of finished sheets
- Reduced production of scrap
- Excellent thermal stability and resistance to light
- improved physical properties

FIGURE 2
PROCESSING CHARACTERISTICS OF PVC



Unmodified PVC compound. Note lack of rolling bank shredded edges, air streaks, rough surface.

PVC compound with INDOFIL K-120ND processing aid. Note smooth rolling bank, well-knit edges. Smooth glossy surface.

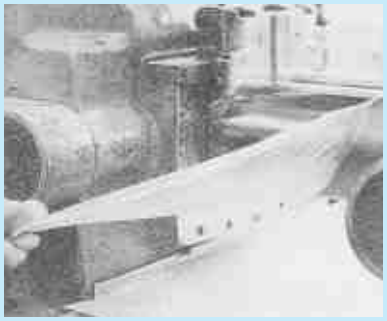
FIGURE 2
HOT STRENGTH OF STRETCHED PVC

Unmodified PVC

FIGURE 3
EFFECT OF INDOFIL K-120ND ON PLATEOUT

Plateout on mill rolls

Plateout eliminated with INDOFIL K-120ND Procession aid.



PVC containing INDOFIL K-120ND processing aid

4.2 Extruded Sheet

Many advantages of using Indofil K-120ND processing aid in calendering operations also apply to the manufacture of extruded sheet. Uniform flow of the melt prevents surging at the die face, producing sheets of close dimensional conformance. The Excellent dispersion of Indofil K-120ND processing aid results in sheets that are smooth and glassy with a high degree of clarity. Typical starting-point formulations for calendered and extruded PVC sheet and film are presented in Table 5. Table 6 lists physical properties of extruded PVC sheet(12-40 mil thickness) & Table 7 lists those of extruded PVC film (1 and 3 mil thickness) made from a typical compound.

TABLE 5
Calendered and Extruded PVC sheet and film Formulations

	PARTS		
Ingredients	Clear	Opaque	Non-Stress Whitening Clear
PVC (K=58 to 60)	100	100	100
Indofil KM-350	8 to 12	6 to 10	10 to 15
Indofil K-120ND	2.0	2.0	2.0
Indofil PMA-175	0.5 to 1.0	0.5 to 1.0	0.5 to 1.0
Tin Stabilizer*	1.5 to 2.0	1.6 to 2.0	1.5 to 2.0
Glyceryl Monostearate	0.5 to 0.8	0.5 to 0.8	0.5 to 0.8
Monotan Ester Wax	0.2 to 0.4	0.2 to 0.4	0.2 to 0.4
Monotan Acid Ester Wax	0.05 to 0.2	0.05 to 0.2	0.05 to 0.2
Blue Toner (1% in PVC)	0.06	-	0.06
Titanium Dioxide	-	As needed	-

*Octyl for food grade; methyl or butyl for general purpose.

TABLE 6
Physical Properties of Extruded PVC Sheet

Thickness, mills	12		20		40	
Falling Dark Impact Strength ft/lbs at 23^{0}C	4.5		10.1		30	
	Machine	Cross	Machine	Cross	Machine	Cross
Elongation at Break, %	74	38	105	18	15	12
Tensile Strength at Break, Mpa	89	60	70	61	58	53
Tensil Modules, Mpa	2745	2662	2485	2420	1276	1903
Toughness, in.lbs/in^3.	7200	2760	8320	1170	1010	770
Tear Strength, in.lbs/mil of thickness	0.332	0.245	0.412	0.291	0.594	0.329

FORMULATION:	**PARTS**
PVC (K=62)	100
Indofil K-120ND	3
Tin Stabilizer	2.25
Glyceryl Monostearate	0.8
Montan Ester Wax	0.2
Toner	0.06

TABLE 6 A
Blow-Molded Bottle Formulations

Ingredients	Parts	
	General purpose	Food Grade
PVC (K=58)	100.00	100.00
Indofil KM 350	12.00	12.00
Indofil K-12 ND	2.00	2.00
Indofil PMA-175	0.50 to 1.00	0.50 to 1.00
Tin Stabilizer	2.00	2.00 to 2.20
Glyceryl Monostearate/Oleate	0.50	0.50
Montan Ester Wax	0.20	0.20
Blue Toner (1% on PVC)	0.06	0.06

4.3 Blow-Molded Bottle and Packages

Indofil K-120ND processing aid is an important ingredient of impact-modified vinyl formulations for blow-molded bottles and packages. Two to three parts of Indofil K-120ND processing aid assure smooth trouble free processing in blowmolding machinery. The excellent cohesion and hot strength imparted to the parison result in glossy clear molded parts that are free from melt fracture, Blow molded containers exhibit uniform wall thickness and bottle weight, Typical blow-molded bottle formulations containing Indofil K-120ND processing aid Indofil KM-350 impact modifier, and Indofil PMA-175 lubricating processing aid are presented in table 6A.

4.4 Blown Film

The excellent dispensability of Indofil K-120ND processing aid in PVC compounds is particularly beneficial in low work processes such as blow molding and the manufacture of blown film. Film formulated with Indofil K-120ND processing aid has exceptional smoothness and clarity and an almost complete lack of fish eyes. The physical properties of blown film made from a compound containing two parts of Indofil K-120ND processing aid are presented in Table 7.



TABLE 7
PHYSICAL PROPERTIES OF EXTENDED AND BLOWN PVC FILM

Thickness, mils	0.25		0.75	
Falling Dart Impact Strength, ft.-lbs.				
23°C	35		288	
0°C	-		155	
-18°C	-		127	
Moisture Vapor Transmission Rate g/100in²/day	6.9		0.8	
Permeability cc.100in²/day				
Oxygen	31		5.3	
Nitrogen	16		1.6	
Carbon dioxide	75		13	
Coefficient of Friction				
Static	0.438		0.329	
Kinetic	0.409		0.292	
MIT Fold Endurance Test, Flexes to Break				
23°C	-		3600	
0°C	-		2900	
	Machine	Cross	Machine	Cross
Tear Strength, in.-Lbs./mil thickness	0.171	0.136	0.136	0.149
Tensile Elongation at Break, %	79.000	29.000	133.000	105.000
Tensile Stress, max Mpa	65.000	64.000	68.000	81.000
Tensile Strength at Break, Mpa	63.000	61.000	65.000	81.000
Tensile Modulus, Mpa	3210.000	3230.000	3030.000	3940.000
Toughness, in –lbs./in.³	5970.000	2400.000	19.480	10.560

FORMULATION:	**PARTS**
PVC (K=62)	100.00
Indofil K-120ND	
Processing Aid	2.00
Tin Stabilizer	2.25
Glyceryl Monostearate	0.70
Montan Ester Wax	0.30
Toner	0.03

4.5 Plasticized Sheet and Film

In PVC formulations containing 50 phr DOP plasticizer and up to 5 phr Indofil K-120ND, the fluxing time is reduced and appearance improved in comparison to formulations not containing Indofil K-120ND. Indofil K-120ND has superior dispersibility in systems subjected to relatively low shear. In processing the unmodified PVC, no rolling bank is formed and the sheet shows many air streaks and poor clarity. The modified compounds exhibit good rolling bank, have no air streaks, and showed improved appearance, color and clarity.

In making 30-mil sheet, tensile strength increased with increasing levels of processing aid, but the stiffness (modulus) begins to rise when the concentration of processing aid is above five phr. To devise a formulation of optimum composition and performance, the molecular weight of the vinyl resin, the amount and efficiency of the plasticizer, the thickness of the sheet, and the design and operating parameters of the equipment must be taken in to account. In addition, the greater hot strength imparted to vinyl compounds by Indofil K 120ND processing aid is beneficial to the preparation of blown film and vacuum formed parts.

Indofil K-120ND processing aid controls plateout in plasticized vinyl as it does in rigid compounds.

TABLE 8
Processing Pigmented Plasticized PVC Sheet and Film at 160°C

Modifier, parts	0	2	5
Rolling Bank[a]	F	G	G+
Appearance,10-mil Film[a]	P	G	E
20-mil Sheet[a]	F-P	G+	E
40-mil Sheet[a]	F-P	G+	E
75-mil molded slab			
Tensile Strength, Mpa	18.4	19.3	19.4
Ultimate Elongation %	380.0	390.0	395.0
100% Modulus, Mpa	8.8	9.1	9.0
T_f, °C	-22.5	-22.0	21.5

FORMULATION:	**PARTS**
PVC (K=75)	100-X
Indofil K-120ND	X (0-5)
DOP	50.0
Barium/Cadmium Stabilizer	1.7
Calcium Carbonate	5.0
Pigment Dispersion[b]	5.0

[a]Rating: F = fair; G = Good; G+ = Very Good; E = Excellent
[b]10% disperation of blue phthalocynine pigment in Indofil G-54 (Polymeric Plasticizer)

4.6 Foamed Products

Indofil K-120ND acts as a supporting processing aid to the primary high molecular weight processing aid to the primary high molecular weight processing aid used for all foamed applications such as foamed rods, sheets & profiles, photo frames, foam pipes & cellular door & window frames.

It is capable of acting alone only in small width profiles and sections like photo frames profile. Indofil K-120ND does improve defect free surface characteristics in addition to maintaining output consistency.

INDOFIL K-120 ND
Your Key Assistant in all PVC applications