CYTEC

Energy Curable Renewable Raw Material

2 Cytec's Contribution to Sustainable Change

Sustainability means living our values in a changing world, including development of innovative and environmentally sustainable products that compete in a global economy; achieving the highest standards of safety, health and environmental stewardship; and being responsible to our stakeholders.

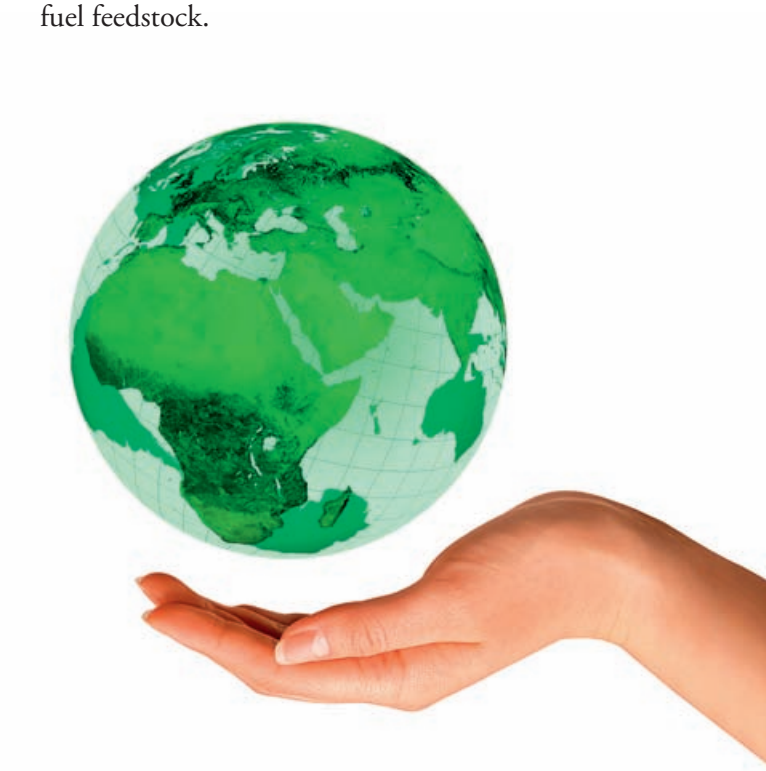
Consumers, and suppliers of consumer products, are taking an increasingly active interest in environmental issues and sustainable development.

Cytec has adopted Anastas and Warner's **12 Principles of Green Chemistry*** in its efforts to develop, manufacture and promote innovative products that meet or exceed our customer requirements for technical performance and eco-friendliness. In accordance with this framework Cytec is developing and promoting energy curable resins that have moderate to high content of **Renewable Raw Material**.

Inks and coating products formulated with renewable components tend to reduce the environmental footprint of the final products as compared to those formulated with non-renewable components. Cytec believes in the collective effort of the industry to develop more renewable products that will eventually reduce dependence on extractive resources.

EBECRYL™ and EBECRYL bioligomers (US market) are the range of resins containing renewable raw materials that Cytec offers to the formulators to make a difference towards a Sustainable Change in the coatings market.

Seeds oils, starch and cellulose from straw and wood are only some of the renewable used in the manufacture of chemical substances and products. By employing physical, chemical and biochemical processes these materials can be converted into chemical intermediates, polymers, lubricants, solvents, surfactants and specialty chemicals to co-replace traditional fossil fuel feedstock.



Renewable raw materials used in EBECRYL™ acrylate resins and EBECRYL 5000 series bioligomers (available in USA) include several derivatives of natural oils and fatty acids.

* P. Anastas, J. Warner in "Green Chemistry: Theory and Practice", Oxford University Press, New York, 1998

3 Industry Drivers for Renewables

The main industry drivers towards a greater reliance on Renewable Raw Materials are:

Responsible Care®: the coatings and inks industry increasingly wishes to demonstrate good product stewardship concerning health and environmental issues.

Sustainability: the industry is becoming more aware of the need to work in a sustainable way. The marketed products must not only be economically viable but also socially and environmentally respectful. Renewable raw material based products can help in achieving this goal of sustainability.

Renewable Resources Definition

Resources that have a natural rate of availability and yield a continual flow of services which may be consumed in any time period without endangering future consumption possibilities as long as current use does not exceed net renewal during the period under consideration. (Source: WHIT)

Calculations

The Renewable Raw Material content (RRM%) and the Naturally Derived Carbon content (NDC %) – also called Biobased Carbon – are calculated accordingly to the formula indicated hereunder.

Functionality: naturally derived materials offer a range of functionalities that contribute to enhance the intrinsic value of these products. A specific example is the improved pigment compatibility obtained with epoxy acrylates modified with naturally derived oils. Another example is the one of energy curable wood primers based on natural oils that provide excellent adhesion and enhance the wood warm color.

$$\text{Weight \% RRM} = \frac{\text{Weight RRM}}{\text{Weight End Product}} \times 100$$

$$\text{\% Biobased Content} = \frac{\text{Amount of Biobased Carbon}}{\text{Amount of Biobased Carbon + Amount of Petroleum Based Carbon}} \times 100$$

DISCLAIMER: The RRM (renewable raw material) and the NDC (naturally derived carbon) content of the products listed here are exclusively based on information received from suppliers for which Cytec cannot be held liable. Cytec makes no representations or warranties as to the accuracy or completeness of confidential information provided in this document.

4 Renewable EBECRYL series

EBECRYL™ polyester acrylates with medium to low viscosity have fair to high renewable raw material content. Their excellent pigment wetting and good adhesion to various substrates makes this range very suitable for ink formulations. Some of these products are highly recommended for litho application thanks to their ink-water balance performances.

EBECRYL epoxy acrylates range includes products that are hard, solvent and water resistant, fast curing. In the fatty acid-modification improves the pigment wetting and the ink water balance in litho inks.

PRODUCT	PRODUCT TYPE	FUNCTIONALITY	VISCOSITY MPA.S @ 25°C	RENEWABLE RAW MATERIAL (W%)	NATURALLY DERIVED CARBON (%)	APPLICATION
EBECRYL™ 450	Polyester acrylate	6	8600	30	35	Main use is in flexo inks. The product gives excellent pigment wetting and high reactivity.
EBECRYL 452	Polyester acrylate	4	600	24	29	Recommended for flexo inks. Excellent pigment wetting enables the production of high concentrated pastes, increasing productivity and process flexibility.
EBECRYL 657	Polyester acrylate	4	125000	42	52	Mainly recommended for offset inks. Good pigment wetting, ink water balance and misting properties.
EBECRYL 1657	Polyester acrylate	4	125000	42	52	Mainly recommended for offset inks. Good pigment wetting, ink water balance and misting properties.
EBECRYL 846	Polyester acrylate	6	45000	15	17	Recommended for high speed offset inks. The product feature high reactivity and low misting.
EBECRYL 870	Polyester acrylate	6	48000	25	30	Excellent pigment wetting and high reactivity. The product is recommended mainly for offset inks.
EBECRYL 1870	Polyester acrylate	6	48000	25	30	Excellent pigment wetting and high reactivity. The product is recommended mainly for offset inks.
EBECRYL LEO 10801	Polyester acrylate	6	45000	24	30	This resin is a very good base to develop inks for indirect food packaging.
EBECRYL 2870	Polyester acrylate	6	48000	25	30	Resin recommended for offset inks. Excellent pigment wetting and high reactivity.
RAYLOK™ 1124	Polyester acrylate	4	3200	37	40	The product is recommended as very good base resin to formulate sealers for parquet flooring.
RAYLOK 1621	Polyester acrylate	2+1	520	27	31	Low viscosity natural oil modified acrylate oligomer. It combines air drying and UV curing properties. Used in a clear coat for wood it gives transparent oil-like natural aspect.
RAYLOK 1622	Polyester acrylate	3	520	21	23	Low viscosity natural oil modified oligomer acrylate. Used in a clear coat on wood it gives a transparent oil-like natural and warm aspect.
EBECRYL 860	Epoxidized soja	3.5	25000	60	71	Perfect for developing overprint varnish where hot foil stamping is required.
EBECRYL 3608	Fatty acid modified epoxy acrylate	2	70000	7	16	Product recommended for ink formulations where improved pigment wetting is demanded.
EBECRYL 3702	Fatty acid modified epoxy acrylate	2	900000	16	16	Product recommended for ink formulations, good litho behavior and very good pigment wetting.

* Raylok 1124: only available in USA

EBECRYL bioligomers 5000 series

EBECRYL bioligomers 5000 series are energy curable products based on renewable resources developed for the US market (not EINECS listed).

These innovative products allow for the formulation of partially renewable inks and coatings without the loss of printability, pigment wetting or performance properties.

PRODUCT	PRODUCT TYPE	FUNC-TION-ALITY	VISCOSITY mPa.s @ 25°C	RENEWABLE RAW MATERIAL (W%)	NATURALLY DERIVED CARBON (%)	APPLICATION
EBECRYL bioligomer 5601	Epoxidixed Soya Oil Acrylate	3.5	26500	62	62	Recommended for overprint varnishes, screen inks and flexographic inks.
EBECRYL bioligomer 5610	Modified Bisphenol A Epoxy Diacrylate	2	2200	12	12	Recommended in overprint varnishes, clear coatings for paper and plastics, screen inks, and wood fillers. Films of EBECRYL 5610 cured by UV or EB exhibit high gloss, good surface hardness, and excellent chemical resistance.
EBECRYL bioligomer 5801	Polyester Acrylate	3	6000	52	58	Excellent product recommended to formulate flexographic pigment dispersions and inks for porous and nonporous substrates.
EBECRYL bioligomer 5820	Polyester Tetraacrylate	4	66100	51	56	Recommended for wet or dry offset inks, formulated for porous substrates. This mode-rate viscosity polyester acrylate exhibits good pigment wetting, color development and printability.
EBECRYL bioligomer 5821	Polyester Pentaacrylate	5	27500	31	37	Recommended for wet or dry offset inks, formulated for porous substrates.
EBECRYL bioligomer 5822	Polyester Pentaacrylate	5	29200	34	37	Specifically developed for black and pigmented UV/EB lithographic inks. Recommended for wet or dry offset inks, formulated for porous substrates.

6 What Makes Energy Curable Products Renewable?

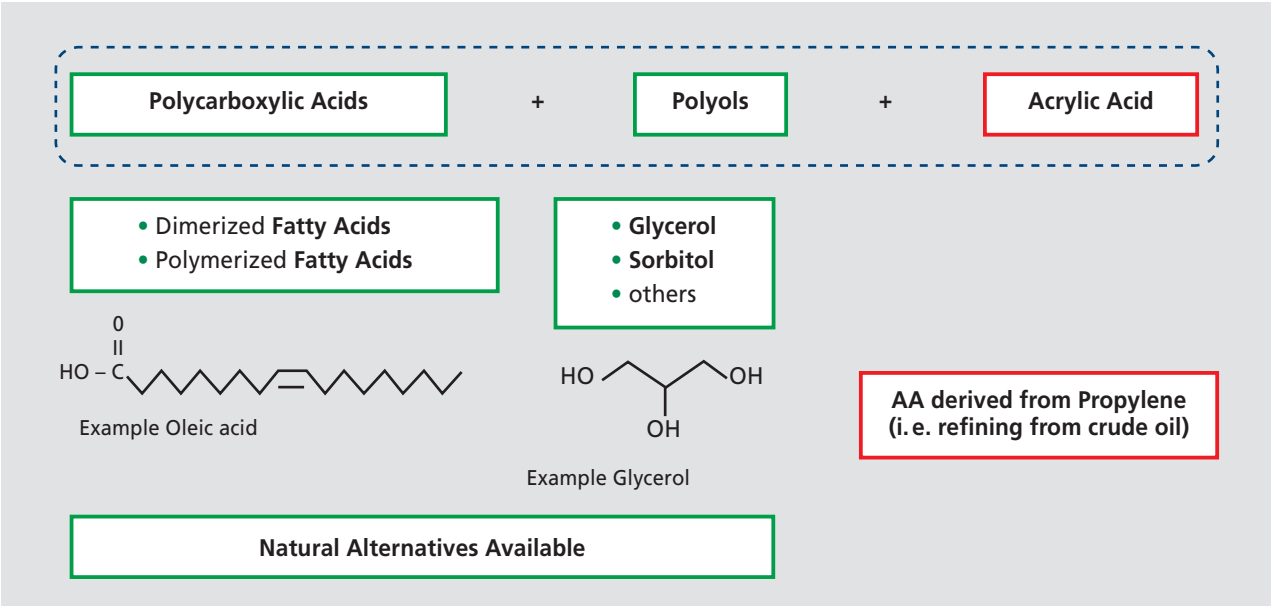
Although the majority of the raw materials used to produce energy curable acrylates are of petrochemical origin, Cytec is striving to increase the use of renewable raw materials for the production of radiation curable products.

A complete acrylation of epoxidized vegetable oils – such as soya bean oil results in radiation curable epoxy acrylates with renewable raw material content over 60 %.

Polyester acrylates are produced by condensation reaction of polycarboxylic acids, polyols and acrylic acid.

Examples of polyols from renewable source are **glycerol** (a by-product in the production of biodiesel or produced by fermentation of glucose), **sorbitol** and others. Also polycarboxylic acids dimerized or polymerized **fatty acids** can be used. Both epoxy acrylates as polyester acrylates may be modified with fatty acids.

Example of Polyester Acrylate obtained by condensation reaction



It is important to consider that – at present – the major source of acrylic acid (one of the main raw materials for UV/EB curable resins) is produced in the petrochemical industry by oxidation of propylene, a product from the refining of crude oil. However, work is ongoing to produce **acrylic acid** from renewable raw materials. Only this step will enable to strongly increase the renewable content of acrylates and reduce oil dependency of this industry.

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