CITROFLEX INCI NAME Triethyl citrate

SUMMARY
The Citroflex plasticizers, a series of citric acid esters, are compatible with most of the generally useful polymers. This bulletin suggests many ways in which these citric acid esters (Citroflex plasticizers) may be used for specific performance requirements, particularly in applications where toxicological safety meeting the U.S. Food and Drug Administration requirements is of prime importance.

INTRODUCTION
Plasticizers may be defined as high-boiling organic solvents used to impart flexibility to otherwise hard of even brittle polymeric materials. They are high-boiling to avoid loss from the polymers by volatilization, and they possess solvent power to ensure compatibility with resins.

FUNCTION OF PLASTICIZERS
Plasticizers are necessary in making most polymeric materials usable. They make hard polyvinyl chloride resins suitable for use as wrapping film or sheeting. Used with polyvinyl chloride or polyvinyl chloride polyvinylidenen chloride latics, they form continuous heavy duty coatings on paperboards or foil. They make brittle nitrocellulose suitable for use in lacquers. They make tough cellulose acetate suitable for injection molding.

OPERATION OF PLASTICIZERS
Plasticizaiton may be considered permanent partial solution. It produces partial neutralization of the secondary valence bonds of the polymer molecules. With further neutralization of the secondary valence bonds produced by adding greater amounts of plasticizer, the polymer molecules become less strongly bound to each other. The physical properties of the polymer are changed by the bond neutralization: tesile strength is lowered, elongation and flexibility are increased, and softening temperature and brittle temperature are lowered. Softening of the polymer also increases as the amount of plasticizer is increased.

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it

CITROFLEX INCI NAME Triethyl citrate

SELECTION OF PLASTICIZERS

The selection of plasticizer largely depends on the intended use of the polymer. Plastic products with thin cross sections or those exposed to high temperatures require plasticizers with very low volatility. Plastics with thicker cross sections, or those, which may be exposed to less severe temperature conditions, can use more volatile plasticizers. The federal Food, Drug and Cosmetic Act provides that a food is misbranded if its container is composed, in whole or part, of any poisonous or deleterious substance which may render the contents injurious to health. In view of this provision, the wisdom of obtaining prior Food and Drug Administration acceptance of plasticizers in plastic food-wrapping materials is obvious. Food and Drug Administration acceptance is granted only after satisfactory completion of long-term feeding studies with more than one species of animal.

THE CITROFLEX FAMILY OF PLASTICIZERS

Citroflex plasticizers are unique in that they are all derived from citric acid, a tribasic monohydroxy acid well known its numerous food applications. Trietyl citrate (Citroflex 2) has been accepted for use as a food additive and as plasticizer in plastic food wraps by the U.S. Food and Drug Administration. Acetyl triethyl citrate (Citroflex A-2) has been accepted for use as a plasticizer in plastic food wraps by the U.S. Food and Drag Administration and the Meat Inspection Branch of the U.S. Department of Agriculture Acetyl tributyl citrate (Citroflex A-4) has been accepted for use as a plasticizer in plastic food wraps by the U.S. Food and Drug Administration, the Bureau of Animal Industry, and the Office of the Quartermaster General. Acetyl triethyl citrate (Citroflex A-2) and acetyl tributyl citrate (Citroflex A-4) have both been accepted for use as plasticizers in aerosol hair sprays and bandages by the U.S. Food and Drug Administration. The Keuringsdienst van Waren of the Netherlands, equivalent to the U.S. Food and Drug Administration, has accepted triethyl citrate (Citroflex 2), acetyl tributhyl citrate (Citroflex A-4) for use as plasticizers for plastic food wraps.

IDENTIFICATION

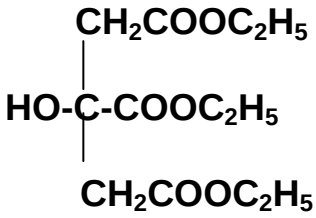
Citroflex plasticizer may be easily identified by their numerical suffixes, which correspond to the number of carbon atoms of the alcohol used in preparing the ester. The acetylated esters are distinguished by the letter “A” appearing before the number. Thus triethyl citrate is identified as Citroflex 2,while acetyl tributyl citrate is called Citroflex A-4.

Name	Formula
CITROFLEX 2 (Triethyl Citrate)	CH2COOC2H5 HO-C-COOC2H5 CH2COOC2H5
CITROFLEX A-2 (Acetyl Triethyl Citrate)	CH2COOC2H5 CH3COO-C-COOC2H5 CH2COOC2H5
CITROFLEX A-4 (Acetyl Tributyl Citrate)	CH2COOC4H9 CH3COO-C-COOC4H9 CH2COOC4H9

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it

CITROFLEX INCI NAME Triethyl citrate

CITROFLEX 2 (triethyl citrate)



Citroflex 2 exhibits a high degree of compatibility with vinyl resins and cellulosic derivatives. It also has solvating action for natural resins such as dammar and ester gums and is especially recommended as a solvent plasticizer for cellulose acetate and other cellulosic derivatives. It enhances the grease resistance of formulations because of its limited oil solubility. Its light-fastness makes it desirable for lacquer formulations. Citroflex 2 does not support fungous growth. Triethyl citrate (Citroflex 2) has been accepted for use as a food additive in U.S.A. and as a plasticizer for plastic food wraps by U.S. Food and Drug Administration. Triethyl citrate (Citroflex 2) has been accepted for use as a plasticizer in plastic food wraps by the Keuringsdienst van Waren of the Netherlands. In Japan, Citroflex 2 is used as a diluting solvent of fragrance, in which Cosmetics company recommends to use. INCI NAME Triethyl citrate. It is a safe raw material and can also reduce the bacteria on the skin by making the skin more acid.

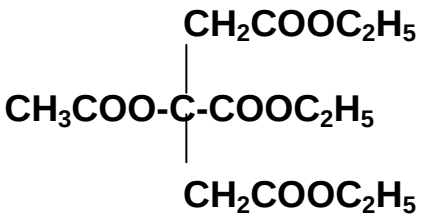
Compatibility	Citroflex 2
Cellulose Acetate	C
Cellulose Acetate-Butyrate	C
Cellulose Nitrate	C
Chlorinated Rubber	C
Ethyl Cellulose	C
Polyvinyl Acetate	C
Polyvinyl Butyral	C
Polyvinyl Chloride	C
Polyvinyl Chloride-Acetate	C
Polyvinyl-Vinylidene Chloride	C

C=Compatible

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it

CITROFLEX INCI NAME Triethyl citrate

Citroflex A-2 (acetyl triethyl citrate)



Citroflex A-2 is a solvent plasticizer for cellulosics and is especially recommended as a plasticizer for ethyl cellulose. Cellulose acetate compositions with low wrapping characteristics may be prepared with this ester. Its light-fastness makes it suitable for lacquer formulations. Acetyl triethyl citrate (Citroflex A-2) has been accepted for use as a plasticizer in plastic food wraps by the U.S.Food and Drug Administration and Meat Inspection Branch of the U.S.D.A. Acetyl triethyl citrate (Citroflex A-2) has been accepted for use as a plasticizer in aerosol hair sprays and bandages by the U.S. Food and Drug Administration. Acetyl triethyl citrate (Citroflex A-2) has been accepted for use as a plasticizer in plastic food wraps by the Keuringsdienst van Waren of the Netherlands. In Japan, Citroflex A-2 is used as a plasticizer of nail polish.

Compatibility

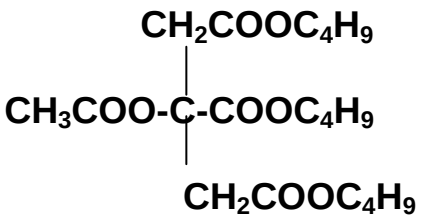
	Citroflex A-2
Cellulose Acetate	C
Cellulose Acetate Butyrate	C
Cellulose Nitrate	C
Chlorinated Rubber	C
Ethyl Cellulose	C
Polyvinyl Acetate	C
Polyvinyl Butyral	C
Polyvinyl Chloride	C
Polyvinyl Chloride Acetate	C
Polyvinyl Vinylidene Chloride	C

C=Compatible

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it

CITROFLEX INCI NAME Triethyl citrate

CITROFLEX A-4 (acetyl tributyl citrate)



Citroflex A-4 is the preferred plasticizer for food packaging, because of its pharmacological safety, economy, performance and lack of odor. Long-term feeding tests with two species of animals, carried out by a leading medical research laboratory with methods required by the U.S.Food and Drug Administration, have shown the pharmacological safety of A-4. Acetyl tributyl citrate (Citroflex A-4) has been accepted as component of plastic food wraps for use with all foods, including fatty foods, by the Food and Drug Administration and has been accepted as a component of plastic meat wraps by the Bureau of Animal Industry and by the Office of Quartermaster General. A recent summary of toxicity studies of plasticizers accepted by the Food and Drug Administration showed acetyl tributyl citrate (Citroflex A-4) pharmacologically to be one of the safest compounds. Acetyl tributyl citrate (Citroflex A-4) has been accepted for use as a plasticizer in aerosol hair sprays and bandages by the U.S. Food and Drug Administration. Acetyl tributyl citrate (Citroflex A-4) has been accepted for use as a plasticizer for plastic food wraps by the Keuringsdienst van Waren of the Netherlands. Odorless Citroflex A-4 is outstanding as a food-packaging plasticizer. Odorless Citroflex A-4 may be used with the most delicate foodstuffs without odor pickup. Thus it is suitable for dairy product cartons, soft drink bottle caps, preserve jar cap seals and other applications demanding odorless components. Acetyl tributyl citrate (Citroflex A-4) is one of the most economical plasticizers accepted by the Food and Drug Administratoin.It is economical, not only a cost basis but also on a performance basis. It is an efficient plasticizer, with excellent compatibility for polyvinyl chloride, polyvinyl chloride-polyvinyl acetate copolymer, and polyvinyl chloride – polyvinylidene chloride copolymer. Resins plasticized with Citroflex A-4 possess excellent flexibility at low temperatures. They exhibit excellent heat stability, thus avoiding discoloration during sealing operations. The citrate molecule has a stabilizing effect on many resins. Citroflex A-4 may be milled into sheet and film as stocks prepared with this ester process very easily. Citroflex A-4 may be used for solution-coating operations on paperboard and foil. It may be used with vinyl lattices, either added as emulsion to the latex or incorporated in preplasticized latex supplied by the manufacturer. Citroflex A-4 is the preferred plasticizer in flexible vinyl toys for children. Its lack of odor and its non-toxicity are important features for the toy manufacturer concerned with child safety. In addition to those applications requiring non-toxicity, Citroflex A-4 is an excellent general-purpose plasticizer. Cellulose nitrate films plasticized with this ester have lower volatility loss, better resistance to yellowing and better adhesion to metals than cellulose nitrate films plasiticized with dibutyl phthalate.

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it

CITROFLEX INCI NAME Triethyl citrate

Compatibility

Cellulose Acetate	SI
Cellulose Acetate-Butyrate	SI
Cellulose Nitrate	C
Chlorinated Rubber	C
Ethyl Cellulose	C
Polyvinyl Acetate	C
Polyvinyl Butyral	C
Polyvinyl Chloride	C
Polyvinyl Chloride-Acetate	C
Polyvinyl-Vinylidene Chloride	C
C=Compatible	SI=Slightly Incompatible

Performance of Citroflex A-4* in Bakelite Resin VYNW**

Properties		
Modulus,100 Elongation	(ASTM D 412-41)	psi 1400
Tensile Strength	(ASTM D 412-41)	psi 2600
Elongation	(ASTM D 412-41)	% 340
Tear Resistance	(ASTM D 1004-49 T)	lb/in thickness 310
Brittle Temperature	(ASTM D 746-44 T)	25
Volatile Loss Form 4 Mil film	(ASTM D 1203-52 T)	7.2
Water Resistance		
Absorption	(ASTM D 570-42)	% gain 0.24
Soluble Matter		% loss 0.13
Oil Resistance	(ASTM D 543-43)	% loss 0.60

*Concentration is 50 parts per hundred of resin VYNW
** Trademark, Union Carbide and Carbon Corporation

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it

CITROFLEX INCI NAME Triethyl citrate

PACKAGING

CITROFLEX 2 Net 15 kg tin can, Net 200 kg Steel drum

CITROFLEX A-2 Net 15 kg tin can, Net 200 kg Steel drum

CITROFLEX A-4 Net 18 kg tin can, Net 215 kg Steel drum

REFERENCES

1. Lehman, A.J. Chemicals in foods: A report to the Association of Food and Drug Officials on current developments, Part I, Assoc. Food & Drug Officials U.S., Quart. Bull, 15, 82 (1951)

2. Personal communication, R.M. Mehurin, Bureau of Animal Industry, U.S. Department of Agriculture (1950)

3. Personal communication, Lt. Colonel R.M. Denny, Office of the Quartermaster General, Department of the Army (1951)

4. Lehman, A.J., Chemicals in foods: A report to the Association of Food and Drug Officials on current developments, Plastic packaging materials, Assoc. Food & Drug Officials U.S., Quart. Bull., 18, 129 (1954)

5. Brown, A. E., Mod. Plastics, 23, 189 (1946)

6. Unpublished data, Chas. Pfizer & Co., Inc.

7. Matheson, L. A. and Boyer, R.F., U.S. Patent 2,429,165 (1947)

8. Corwin, J.F. and white, R.C., U.S. Patent 2,271,389 (1942)

9. Wilson, R.H. and McCormick, W.E., Toxicology of plastics and rubber plastomers and monomers, Ind. Med. and Surg., 23, 479 (1945)

CBC (EUROPE) Ltd. Ufficio di Milano
Via E.Majorana 2 - 20054 - Nova Milanese (MI)
Tel. +39 (0)362 365079 Fax. +39 (0)362 41273
E-Mail: chemical@cbc-europe.it www.cbc-europe.it