

Handbook of
**Antiblocking, Release,
and Slip Additives**
3rd Edition

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INTRODUCTION

1.1 HISTORICAL DEVELOPMENTS

Surface blocking was a technological hurdle for as long as humans began to process materials. In ancient times natural products were used to improve technological output and quality. These included beeswax, plant waxes, natural resins, oils, etc. They were used advantageously in cosmetics (e.g., creams used by Cleopatra in Egypt), plasters (e.g., wall plasters in Pompei, Italy), molds, etc.

The priority of application of modern additives is not documented in research publications but the use of antiblocking, release, and slip agents is a rather recent advancement of technological processes. This is easy to predict, knowing the origin of several materials involved in their production. Stearic acid is the oldest synthetic material used in material processing. It was first obtained by the French chemist Chevreul who began studies of soaps and isolated the most common fatty acids. In 1825, together with Gay-Lussac, Chevreul patented the use of stearic acid in candle manufacturing. It took about a century to apply stearic acid in polymer processing. Calcium stearate was first used for commercial purposes by Harrison in 1924.¹

Crambe abyssinica, which is a cool-season oilseed containing large concentrations of erucic acid, was introduced in the United States of America in 1940 by the Connecticut Agricultural Experiment Station.² About 39% of high-erucic-acid oils are now used for production of erucamide, which is a common slip agent.²

The first major paper on mold release was published in 1946 by Ziegler.³ It contained a thorough analysis of the influence of mold material on release properties. Even more important, the paper³ contained a proposal for a new method of mold release testing, which gave the fundamental tool for rational analysis of the problem. More than twenty of the so-called “mold lubricants” were tested by the newly developed pull-out force method. In addition, the effect of “lubricant” on product clarity was observed – both results being considered in the final selection. In the best cases, the decrease of up to 80% of pull-out force was obtained with these tested “lubricants”. Plasticizers and pigments were also found to facilitate mold release properties in combination with mold release agents.

Film wrapping and handling characteristics were of major concern for film producers and these prompted studies of slip agents. The first major paper on the

improvement of the friction coefficient of polypropylene film was published in 1966⁴ but in the 1950s, studies and inventions were already reported on the subject. Polymer selection, concentration of fatty acid amide, and its migration to the film surface were compared with the coefficient of friction of the resultant film.⁴

Also, in the same period of time, the quality and output of blown film suffered, which led to the first major study on elimination of blocking during production of blown film. The study was published in 1967 but some patents had already been issued in the 1950s.⁵⁻⁷ In this first broader study, various fatty acids were tested to establish their performance in solving processing problems. In addition to blocking, the effect of bubble gas (ammonia or air) and the effect of antiblocking agent on film clarity were considered.⁵

The above shows that the modern machinery gradually being introduced after the Second World War influenced a search for additives which may contribute to more efficient production and better quality of materials. Antiblocking, release, and slip agents are very recent additions to formulations of plastics but very important for today's technology.

1.2 EXPECTATIONS FROM COMMERCIAL ADDITIVES

Some literature sources⁸⁻¹⁵ generalize expectations from these three types of additive groups. It is interesting to evaluate the list of these expectations as well as to compare them between the groups to form a base for selection of required products, definition of the groups, and classification of their members. All three groups affect many similar properties. Their direct comparison will better point to their differences (Table 1.1).

Table 1.1. Performance indicators and their potential effects on acceptance of antiblocking (A), release (R), and slip (S) additives

Performance characteristics	Effect	A	R	S
Surface roughening ⁸	spacing effect	S	S	N
Particle size distribution ⁸	yield and performance	S	N	N
Specific surface area ⁸	friction coefficient and wear	S	N	N
Dusting ¹³	health	S	N	N
Chemical inertness ¹⁹		S	N	N
Density ⁸	product weight	S	N	N
Dispersibility ^{13,14}	quality and process time	S	S	S
Number of particles on surface ¹⁴	efficiency	S	N	N
Homogeneity ¹³	handling	Y	Y	Y
Low moisture pick up ¹³	processing cost, quality	Y	S	S
Purity ¹⁴	degradation, toxicity	Y	Y	Y
Color ¹⁵	cost of color correction	Y	Y	Y

Table 1.1. Performance indicators and their potential effects on acceptance of antiblocking (A), release (R), and slip (S) additives

Performance characteristics	Effect	A	R	S
Haze ¹⁹	increase with concentration increase	Y	Y	Y
Compatibility ¹⁴	optical properties	S	S	S
Refractive index ¹⁵	clarity, haze	S	N	N
Compatibility with polymer ^{8,19}	migration to surface	S	Y	L
Low transfer to material in contact ¹²	migration to coextruded layers	S	Y	Y
Inertness to one contact surface ¹⁰	ease of separation	N	Y	N
Adhesion to hot metal surface ⁹	demolding temperature, distortion	N	Y	N
Surface tension ¹⁰	wetting, migration to surface	S	Y	Y
Good spreading characteristics ¹¹	formation of film on mold	N	Y	S
Improved mold flow ¹⁸	lubrication	S	S	Y
Oxidation and thermal stability ¹⁸	oxygen permeability reduced	S	Y	Y
Weathering ¹⁸	protective layer	S	Y	Y
Non-interference with polymerization ¹¹	properties of product	S	Y	Y
Non-interference with peroxide cure ¹⁸	composition	S	S	S
Interaction (A and S)	synergism or inhibition	Y	N	Y
Residue on product ⁹	adhesion, welding	S	Y	Y
Reduced surface tack ¹⁸	protective film/surface roughness	Y	P	P
Non-staining ¹⁸	inert layer on surface, low adhesion	S	Y	Y
Build up ¹⁰	mold cleaning frequency	S	Y	Y
Non-blooming ¹²	product quality	S	S	Y
Toxicity ¹⁰	health and safety	Y	Y	Y
Handling safety ¹⁴	health and safety	Y	S	S
Solvent type and concentration ¹¹	health and safety	S	Y	Y
Food contact approval ¹⁰	health and safety	Y	Y	Y
Low volatility ¹⁰	loss from melt, bubbling	N	Y	Y
High efficiency ¹¹	low concentration required	Y	Y	Y
Wrinkled film	waste/cost	Y	N	Y
Increased line speed ¹⁹	cost	Y	Y	Y
Improvement of production rate ¹⁵	cost	Y	Y	S
Improved mold filling ¹⁸	adjustment of melt rheology	S	S	S
Hardness ¹⁵	equipment wear	S	N	N
Reduced coefficient of friction ¹⁸	surface film	S	Y	Y
Abrasion and scratch resistance ^{18,19}	surface modification	S	Y	Y
Water repellency ¹⁸	hydrophobic properties	S	Y	Y
Improved electrical properties ¹⁸	some are antistatics	S	S	S

Table 1.1. Performance indicators and their potential effects on acceptance of antiblocking (A), release (R), and slip (S) additives

Performance characteristics	Effect	A	R	S
Static charge formation ¹⁹	difficult dispersion	Y	N	N
Price ¹⁴	cost	Y	Y	Y

Performance characteristic expected – Y, expected for some additives – S, not expected – N, low – L, possible – P.

1.3 DEFINITIONS

Merriam-Webster's Dictionary describes blocking of paper as sticking together under the influence of heat and pressure. This is quite a precise definition of blocking, which is an adhesion between materials (usually of the same kind), which makes it difficult to separate them. The blocking is mostly associated with polyethylene and polypropylene films, but it may affect any other product.^{14,16}

Antiblocking is an action, usually carried out by reformulation (addition of antiblocking agent(s)), which aims at reduction of forces of adhesion between the materials in contact. Other components of formulation and/or physical parameters are essential and these are considered throughout the entire book.

The meaning of release is defined as a removal of the force or its effect. This may be related to a material in a flowing form (e.g., melt) or in a solid state. In the case of liquid form, the release properties are usually balanced by the use of external and internal lubricants, which alone or in combination give a proper balance of release and adhesion as it is suitable for efficient processing. In the solid state, release properties are usually required to separate a product from the form in which the product was manufactured. The most likely application of release agents is in the molding industry, but other processes, such as calendering, extrusion, embossing, etc. also require special additives to help in separation of a product from the part of the machine on which the material is being formed.¹⁷ These will all be cases of release agents which mostly act by forming a layer which separates the product and the mold. Sometimes, lowering the coefficient of friction also helps in separation of the product from the mold and this calls for joint use of a release agent together with slip agents discussed below.

To slip means to move with a sliding motion, which implies that a slip agent must address deficiency in the material related to too high a friction between the two surfaces in contact. The surfaces in contact may be composed of the same or different materials. The slip agents are used in both processing and use of manufactured materials.

The above definitions show the differences and similarities in functions of the three groups of additives, which frequently overlap to the extent that assigning their proper functions and designations sometimes becomes ambiguous.

1.4 CLASSIFICATION

Table 1.2 shows chemical groups of materials that are used as either antiblock, release, or slip additives.

Table 1.2. Chemical composition of antiblock, release, and slip agents

Chemical group	Antiblock	Release	Slip
Alcohol phosphates		Y	
Calcium carbonate	Y		
Carbon nanotubes			Y
Cellulose acetate in solution		Y	
Ceramic spheres	Y		
Diatomaceous earth	Y		
Fatty acid amides	Y		Y
Fatty acid esters			Y
Fatty acid salts	Y	Y	Y
Fatty acids		Y	Y
Fluorocompounds		Y	Y
Graphite			Y
Molybdenum sulfide			Y
Kaolin	Y		
Lignosulfonates			Y
Limestone	Y		
Polytetrafluoroethylene		Y	Y
Polyvinylalcohol in solution		Y	
Resins in solution		Y	
Secondary amides	Y		Y
Silica and silicates	Y		
Silicones (oils and crosslinked)	Y	Y	Y
Talc	Y		
Waxes (natural and synthetic)	Y	Y	Y
Zeolites	Y		

There are some areas of overlap in usage of different chemical groups but specific compounds frequently differ in each application (fatty acid amides are a classical example of compounds used in all three applications). One obvious general difference is that inorganic materials are only used as antiblocking additives. Chemical classification is used in the next chapter, which discusses general properties of antiblocking, release, and slip additives.