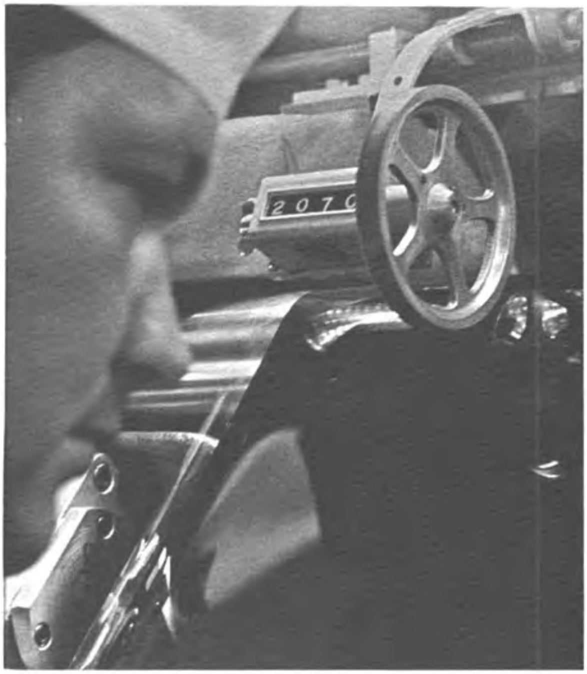
About Kodak Photographic Film



Kodak Park Division,
Rochester, New York

More and more people take pictures every year. Photography is the number one hobby in America. As photography has increased in popularity, so has the interest in how photographic film is made. To answer the questions of educators, students, visitors, and others, Kodak has prepared this description.

Chief raw materials of photographic films include wood fibers, bars of refined silver, cotton linters, petrochemicals, hide trimmings and bones, and the chemical, potassium bromide.

Filmmaking: Art and Science

Raw materials from around the globe go into film. A partial list includes:

Cotton linters—from the South
Wood pulp—from the West Coast
Petrochemicals—from the United States
Silver—from the United States
Hide trimmings—from the United States and abroad
Potassium bromide—from Great Lakes brine deposits

The two chief parts of photographic film are a base and an emulsion. The base is a transparent, flexible sheet on which the emulsion or light-sensitive layer is coated. At present, there are two different kinds of transparent film base produced in large quantities at Eastman Kodak Company.

Cellulose ester film base, such as cellulose triactate, is used in motion-picture film, roll film, film for Kodak Instamatic® cameras, and many other Kodak films.

Estar polyester film base is used when dimensional stability is of utmost importance as in the manufacture of films for x-rays and the graphic arts industry.

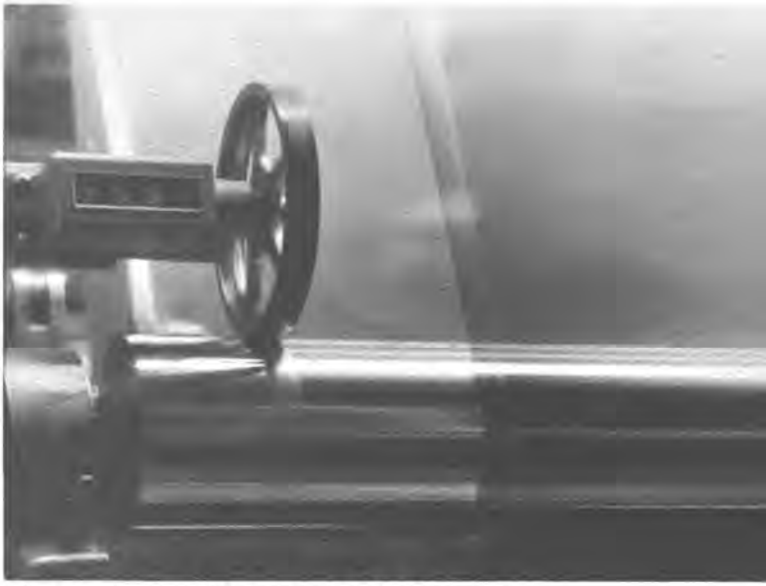
Years ago, only glass was used as a base; today, only very special applications still require glass plates. The use of a thin, flexible base permits film to be sold in rolls as well as sheets and thus makes motion pictures possible. The emulsion is a still thinner layer of gelatine in which light-sensitive ingredients have been suspended. It is the action of light, or certain other forms of radiant energy such as x-rays, upon the emulsion layer that is the basis of photography.

Film Base, the Foundation for Film

Let's begin the story of film production by seeing how a cellulose ester film base such as cellulose triactate is made.

The process starts at Tennessee Eastman Company, Kingsport, Tennessee, a division of Eastman Kodak Company. Cellulose, the raw material for film base, reaches Tennessee Eastman in the form of cotton linters or wood pulp. Because cleanliness is vital in filmmaking, great care is taken in purifying the cellulose before it reaches Tennessee Eastman. If cotton linters are used, the impurities are removed with

Clear, honey-like liquid called "dope" is carefully checked by a technician for contamination.



Film base is wound into large rolls 54 inches wide and thousands of feet long.

caustic soda, the linters are bleached and then the clean cotton is dried. Wood pulp is also specially purified.

The next step is to treat the cellulose in acetic acid, acetic anhydride, and a catalyst such as sulfuric acid. Stainless steel mixers are used. The reaction produces a thick liquid which is stirred and heated until the desired end product, cellulose acetate, has just the right characteristics. This syrup-like liquid is next poured into water, and the cellulose acetate precipitates in the form of pellets, which then are washed and dried. These pellets are shipped to Eastman Kodak Company's Kodak Park Division, Rochester, New York, in bulk tank cars specially designed to protect product quality. There they are mixed with solvents to form a clear, honey-like liquid which is called "dope."

The dope is very carefully filtered to remove any dirt or undissolved material. It is also subjected to a partial vacuum to assist in the removal of suspended and dissolved air which might cause bubbles in the final product.

To form the plastic sheet, the dope must be coated out into a thin layer and the solvents must be removed. The first plastic film base was made in this way on long glass tables. When the solvent had evaporated, the sheet was coated with emulsion; when dry, the coated sheet was stripped from the table and rolled up. Today the glass tables have been replaced and the base-casting part of the operations is accomplished continuously by piping the dope to machines containing highly polished coating wheels 18 feet in diameter and more than five feet wide. A constant flow of dope is spread in a thin, uniform layer on the turning wheel by forcing dope through a very narrow slot. Since the film must be uniform in thickness, this operation calls for extreme care. The standard thicknesses of film base run from 1½ to 8¼ thousandths of an inch.

As the wheel turns, enough solvents evaporate from the dope to permit it to be separated from the wheel as a sheet before a full revolution is completed. More solvents are removed by circulating air around the continuous sheet as it moves over rollers. For easy handling, the base is rolled on cores in long rolls 10,000 feet or more in length. These are then ready to go to the sensitizing division where emulsion is coated on the base.

Now let's examine Estar polyester film base. Estar film base is a thermoplastic material which is known as polyethylene terephthalate and which belongs to the class of plastics called polyesters. Polyethylene terephthalate is a high-polymer material that was discovered by the British scientists Whinfield and Dickson during World War II. It has been commercially developed both as a textile fiber and as plastic sheeting, and its unique physical properties have made it a "natural" for film support.

Estar film support differs markedly from cellulose-ester film supports in both basic chemical nature and method of manufacture. The absence of solvent in the making of Estar film support is one of the reasons why Estar base film shows excellent dimensional stability.

The dimensional stability of a film depends on both the film support and the emulsion coated on that support. Recent changes in emulsions have greatly improved a number of the physical properties of these films.

Let's continue to see how emulsions are made.

Film Emulsion, the Image Recorder

Light-sensitive ingredients of emulsions are generally silver salts. These salts and other elements that go to make a modern photographic emulsion are very carefully compounded from their basic raw materials. Kodak starts with silver bullion (99.97 percent pure) which comes in bars weighing about 75 pounds each. The bars are dissolved in nitric acid, and the resulting clear liquid goes into storage tanks. From these tanks the solution is pumped slowly into crystallizers–1,000-

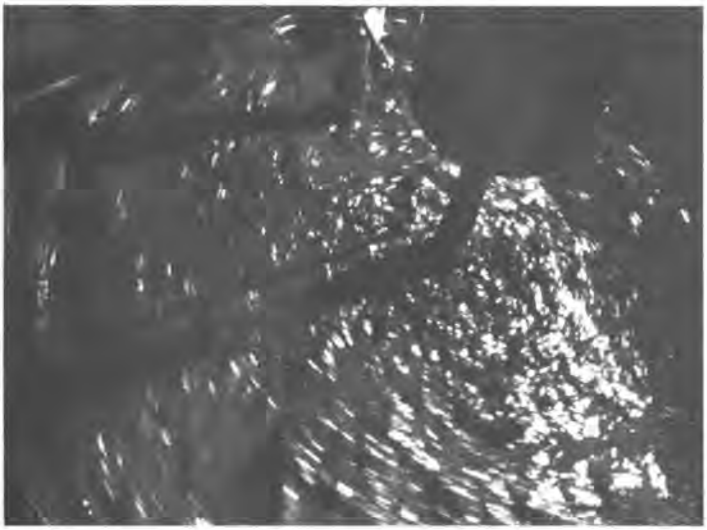
Kodak is one of the world's largest consumers of silver—a major ingredient of film and paper emulsions.

gallon stainless steel tanks—where it is constantly cooled and stirred. This stirring and the addition of some concentrated silver nitrate solution result in the formation and growth of silver nitrate crystals in the lower part of the tank. Soaking wet and resembling common table salt, the crystals then are drawn from the tank into a centrifuge which spins off most of the moisture. The baskets are whirled so that most of the moisture in the crystals is carried off. Each basket contains 60 to 70 pounds of crystals, worth about $600. Next, the crystals are redissolved in distilled water and go through another crystallizing step. After the wet crystals come from the crystallizer the second time and have been whirled until they are only damp, they are dumped into a rotary drying drum. At the other end of the revolving drum the dry crystals pour out. Funneled into stainless steel barrels, each holding $18,000 worth of the product, the dry silver nitrate is ready to be dissolved in warm water for use in emulsion making.

Also used in making the emulsion are potassium iodide, potassium bromide, and gelatine. The gelatine is made by Kodak Park Gelatine Division and by the Eastman Gelatine Corporation at Peabody, Massachusetts, by chemically treating hide trimmings and bones in hundreds of tanks. The stock is then washed and gelatine extracted with hot water. The resulting solution is thoroughly filtered, concentrated by evaporation, chilled, and dried. The processing procedures must be rigidly controlled to produce the high quality gelatines required in photographic emulsions. Careful selection and blending of the gelatine provide the uniformity of the product for use in film and paper emulsions.

Because silver halide crystals are light-sensitive, the next series of steps is carried out in the dark. The blended gelatine is dissolved in pure, distilled water and then water solutions of potassium iodide and potassium bromide are carefully mixed with it. To this heated mixture is added silver nitrate solution, and the desired light-sensitive silver iodide and silver bromide salts are precipitated as fine crystals. Because these crystals are held in suspension by the gelatine, the mix-

Ingots of silver dissolved in nitric acid solution produce silver nitrate crystals.



These crystals are mixed with potassium bromide, gelatine and other chemicals to form a photographic emulsion.

ture is called an "emulsion." The average crystal size and the range of sizes in a given emulsion are important in establishing the characteristics of the film, such as speed, contrast, and fineness of grain.

The emulsion-making process is performed in vessels fitted with agitators to mix the contents, and jackets to provide temperature control. Soluble salts formed during the reaction must be washed out of the emulsion. This is done by chilling it to a jelly, then shredding it and washing the spaghetti-like strands many times with cold water. Then the emulsion is melted, adjusted for desired photographic and physical properties, and carefully tested.

Emulsion Coating

The emulsion then is ready to be coated. It is piped to large machines where, in a continuous operation, rolls of base are unwound and the liquid emulsion is applied to one side. Such machines provide extremely close control of coating thickness uniformity. A dried layer of some emulsions is on the order of six one-hundred-thousandths of an inch thick and is held to within one-millionth of an inch in accuracy. Color products have several successive emulsion layers coated in this fashion—x-ray films are emulsion coated on both sides—

Kodak films are created when the proper emulsion is applied to rolls of the appropriate support material. The process takes place in the dark, and is precisely controlled by skilled operators using highly sophisticated control equipment.

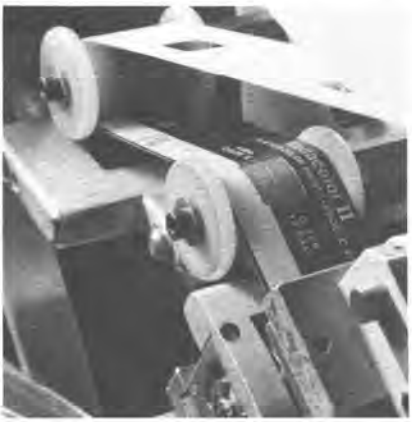
The film is ready for final manufacturing steps after the emulsion coating operations. Here the film is slit to the proper width.

and remember, it is all done in the dark! After the film is coated, it is carried through a chilling box to set and harden the emulsion; it passes through drying sections where it is brought to the correct relative humidity; and finally, it is again wound in long, wide rolls.

Film Spooling and Packaging

Now the film—still in the dark—is ready for the final manufacturing steps. If it is motion-picture film, it must be cut to proper length and width, and perforated accurately so it will operate precisely in the camera and projector and project a steady image on the sceen. The rolls of film are then inspected, wrapped in light-proof paper envelopes, and packaged in sealed cans. The cans are stamped with the emulsion number and footage and placed either in wooden shipping cases or in fiber containers.

If the film is sheet film, it must be cut to the proper size, notched with identifying code symbols, and packaged. In the case of roll film, the film is cut to proper width and wound,



Labels for cartridges to be loaded with Kodacolor II film are fed to the film spooling machines.

Spooled film is further protected by hermetically sealed foil wrap and packaged in familiar yellow cartons.

with backing paper for light protection, on spools. The spooled film is protected by a hermetically sealed foil wrap and then is packaged in the familiar yellow carton. Most film has the expiration date printed on the outside of the box or carton.

After the film is packaged and dated, it is sent to air-conditioned storerooms to await shipment to Kodak marketing regions which, in turn, will forward it to photographic dealers.

A sealed can or sealed metal foil provide desired protection from moisture. Many films also require storage at low temperatures and, at Kodak Park, all are stored in temperature-controlled rooms. Some special films are even refrigerated during shipment.

Strict Quality Assurance

In Kodak's dedication to satisfying customer needs, quality assurance is a key factor. Throughout the design and development of a new product, engineers are guided by product quality objectives and specifications. And prior to the full scale production of a new product, all manufacturing processes and materials are fully tested and evaluated.

Product and quality control engineers develop test methods and equipment, design sampling and audit plans, establish product acceptance criteria and interpret test results. Production and quality data are regularly analyzed to make certain quality program objectives are being met. At all

Packaged and dated film is stored in an air-conditioned warehouse to await shipment to regional distribution points and then on to dealers.

stages of production, photographic tests are made by highly skilled technicians.

Strict specifications for materials and supplies used in making photographic film are established. Many of the product ingredients and accessories are made within the company; e.g., gelatine for photographic emulsions, cartridges for roll film and amateur movie film, and cores for motion-picture film. The company also makes most of its own film boxes and prints many of its labels.

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Kodacolor II (110) film carton and cartridge.

Ask Corporate Information for a free copy of *About Kodak Cameras,* publication number CR1-12.

KODAK UNITS

Rochester, New York—**Kodak Park Division:** photographic films, papers and chemicals. **Kodak Apparatus Division:** still and motion-picture cameras and projectors, lenses, filters, photofinishing and x-ray processing equipment, microfilming and electronic information-handling systems, and special defense work. **Distillation Products Industries:** vitamin concentrates, monoglycerides, laboratory supplies, and specialty chemicals. **Kodak Office:** administrative headquarters of the company.

Windsor, Colorado—**Kodak Colorado Division:** photographic films, papers and lithographic plates.

Kingsport, Tennessee—**Tennessee Eastman Company:** man-made fibers, plastics, industrial chemicals, and materials for the manufacture of photographic film.

Longview, Texas—**Texas Eastman Company:** plastics and industrial chemicals.

Columbia, South Carolina—**Carolina Eastman Company:** Kodel polyester fiber.

Peabody, Massachusetts—**Eastman Gelatine Corporation:** gelatine for use chiefly in the manufacture of photographic films and papers.

Canada—**Canadian Kodak Co., Limited** (Toronto): photographic films, papers, chemicals and cameras.

United Kingdom—**Kodak Limited** (plants at Harrow, Hemel Hempstead, Kirkby, and Stevenage): photographic films, papers, chemicals, cameras, and related products. **Ectona Fibres Ltd.** (at Workington, co-owned by Eastman Chemical International A.G. and Bunzl Pulp and Paper Limited): cigarette filter tow.

France—**Kodak Pathe'**(plants at Vincennes, Sevran, and Chalon-sur-Saone): photographic films, papers, and chemicals; magnetic tape.

Germany—**Kodak A.G.** (Stuttgart): cameras, projectors, and other photographic equipment.

Australia—**Kodak (Australasia) Pty. Ltd.** (Coburg): photographic films, papers, chemicals, and cameras.

Argentina—**Kodak Argentina S.A.I.C.** (Buenos Aires): cameras.

Brazil—**Kodak Brasileira Comercio e Industria Ltda.** (Sao Paulo): photographic papers.

Mexico—**Kodak Industrial, S.A. de C.V.** (Guadalajara): photographic films.