Chemical Control of High Speed Developers

Dave Rogers

Film processing is a many-faceted mixture of art, science, and engineering. The BKSTS Laboratory Committee works hard to ensure that the Society's mission to promote excellence in all areas of the business is made manifest where it is often least considered, but actually matters most – in processing laboratories around the globe. This special "laboratories" feature follows on from the excellent article by Dave Wright of Photomec that appeared in the April [1997] issue [of Image Technology], entitled "That's what the holes are for." Papers on Chemical Control, Laboratory Grading, and Film Printing provide a unique insight into different aspects of film laboratory technology.

Faster and faster

The buoyant film industry and the pursuit of productivity have combined to drive release print developers faster and faster. Technicolor London has high speed machines running at over 650 ft. a minute that can turn out a typical eight reel feature film in twenty minutes. This article explores the chemical control of high speed developers, outlines some new technology, and speculates on the changes that will take place in the next few years.

The basic processes

During high speed processing, release print film passes through a number of baths. First an alkaline prebath softens the remjet backing layer and water jets remove it. A developer bath converts the dye couplers in the film into the dyes that form the picture image and an acidic stop bath halts this process. The first fix bath removes silver halide from the film, and accelerator and bleach baths oxidise silver to silver halide. A viscous "track developer" redevelops silver in the sound track area next to the picture and a second fix removes the silver halide made by the bleach. Finally, stabiliser bath helps to wet the film evenly and driers remove water from the film before it winds onto cores. Water wash baths after the stop, fix, bleach, and track developer prevent contamination of later baths.

Special solutions

Kodak specify formulae for the processing solutions and in some cases have modified them specially, for high speed machines. For example, introduction of a high pH, low bromide, developer allowed a 25% cut in film immersion time and, therefore, increased running speeds. Circulating tanks feeding the developer machine tanks are sampled and analysed regularly by trained Control staff. Sampling frequency varies depending on the bath; developer and stop solutions are sampled and tested several times a day whereas other solutions are sampled and tested daily. Analytical equipment is of high quality and is calibrated regularly, particularly for pH measurement. Adding chemicals to the circulation tanks corrects any deviations from the laid down specifications and trend charts show long term deviations. Analysis often highlights processing problems, for example, high stop pH may indicate excessive carryover of developer solution into the stop bath. Problems are reported immediately to Production supervisors and remedial action is taken.

Continuous replenishment

Processing film uses up chemicals and these are replaced by continuously adding a concentrated replenisher, or boost, solution to the circulating tanks. Kodak specify boost formulae, but these need adapting to suit particular developing machines. High processing speeds inevitably increase the carryover of liquid from one bath to the next and boost chemistry must allow for this carryover. Formulae must also take into account any recycling of surplus solutions used to make up boosts. Recycling chemicals makes economic sense but breakdown products must not be allowed to build up to the extent that they prevent the baths working efficiently. Manipulating boost chemistry to maintain correct levels of chemicals in circulating solutions, is one of the keys to effective control of high speed developers.

Chemical control

Chemical analysis of baths is vital, but photographic "control strips" must be run at regular intervals to monitor developers. Measuring dye and silver levels in the strips with a densitometer confirms that developing and bleaching are satisfactory. Dye levels may be adjusted to match aims by small changes to developer bath temperatures. Chemistry and densitometry go hand in hand and Control staff must have a knowledge of both.

Maintenance

Maintenance is a key factor in high speed processing. Skilled engineers service and inspect developers and ancillary equipment regularly. Acid treatment removes any tar-like deposits from developer baths and biocides prevent build up of algae and other organisms in wash tanks.

Green considerations

Environmental factors are of increasing importance and water boards sample photographic effluents regularly. Solutions of particular concern are fix and fix wash as these contain silver and ammonium thiosulphate. Silver in fix is complexed as the thiosulphate and mostly precipitates as

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"The only way to reduce ammonia and thiosulphate levels in effluent is to maximise recycle of surplus fix into boost mixes, which in turn depends on maintaining low levels of silver in fix circulating solution. The Technicolor London laboratory generates over 7 tonnes of silver a year from high speed developers and recovers the vast majority."

silver sulphide in sewage works. Neither silver thiosulphate nor silver sulphide is believed to be harmful but currently available tests cannot distinguish them from the highly toxic free silver ion. Sewage treatment may not totally break down ammonium salts and they can cause algal growth in receiving water. Thiosulphate is the major contributor to biological oxygen demand in photographic wastes. The only way to reduce ammonia and thiosulphate levels in effluent is to maximise recycle of surplus fix into boost mixes, which in turn depends on maintaining low levels of silver in fix circulating solution. The Technicolor London laboratory generates over 7 tonnes of silver a year from high speed developers and recovers the vast majority. Plate and rotary electrolysis cells remove silver continuously from fix circulating solution and ion exchange resins remove silver from fix washes. Specialist refiners buy and purify the silver that is collected. A large laboratory uses a huge volume of water in its wash baths. Spray washes use less water than deep tank washes and water from one wash tank may sometimes be used in another. Reducing wash flowrate is tempting but care must be taken as contaminating one bath with another can have serious consequences.

New technologies

New technology is continually being introduced. One example is the Toulouse silver recovery cell developed jointly by Kodak France and the University of Toulouse. The Toulouse Cell passes fix through a bed of carbon granules on which silver deposits. A high granule surface area allows low current to be used and fix silver levels of 20 mg/l are achievable, compared with 200 mg/l using conventional electrolytic cells. Another example is the use of resin columns to recover expensive chemicals. Surplus developer solution passes through a column of resin beads which capture the developing agent CD2 and allow impurities to go to drain. Dilute sulphuric acid elutes CD2 from the beads and the resulting CD2 sulphate solution is used to make up developer boost mixes. On line pH measurement is under investigation using new probes that are resistant to the fouling effects of developer chemicals. Kodak is investigating membrane technology for the recovery and reuse of wash water.

Laboratories – the future

So what changes will we see in the future? Sampling and analysis will always have their place but increasingly probes will tell us not only how the solutions are varying but also make the necessary corrections. Developers use continuous chemical processes and will lend themselves naturally to microprocessor control, possibly with the kind of "kit" chemistry used in the minilabs. Recycling and reuse of chemicals and water will rise. Environmental pressure will replace ammonium with sodium based fix. Release print developers of the future will become simpler. Backing free stocks will eliminate prebath. Silver-free dye sound tracks may eliminate track developer and the first fix bath. A single tank bleach may replace the present accelerator and bleach solutions.

Then again, within a few years we might have scrapped our high speed developers and be running dye transfer machines at 800 ft. a minute. Whichever way we go the future holds plenty of challenges and at least as many opportunities.

THE AUTHOR

Dave Rogers graduated from Bristol University in 1972 and joined Glaxo Pharmaceuticals as a research chemist. After three years he moved on to process development and production, and joined Beecham Pharmaceuticals in 1980 to manage a laboratory supporting bulk antibiotic processes. From 1990 to 1994, Rogers was a graduate recruitment manager. He joined Technicolor Services in 1995 and currently serves as technical manager. Rogers is responsible for control and solutions operations at the London laboratory and works closely with film manufacturers and other Technicolor labs on innovations in printing and technology development.