Tableted Chemicals for Medical Film Processing

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1. Preface

In the medical field, where the digital imaging diagnosis has been generalized, the environmental protection has been much concerned. When liquid processing chemicals are employed for processing film, it has been highly requested to obviate the following drawbacks. Processing chemical kits are heavy and need hard work; a large space is required for the storage of the kits and bottle wastes; the solutions stain working area and the like. In order to solve these problems, KONICA Corp. introduced the TC (Tableted Chemicals) Processing System in April 1996 in which unique processing chemical tableting technology was first applied to the minilab market in the world. Since then, the technology has been developed and has made it possible to tablet processing chemicals for medical use. Accompanied with the development of an automatic processor having a built-in chemical mixer for tablets, improvements in work efficiency for film processing and work environment have been achieved. Furthermore, a new developing agent employed as a replacement of hydroquinone has made it possible to decrease remarkably an amount of the replenisher and reduce the processing wastes. At the same time, a large reduction of packaging wastes has contributed to the protection of environment. In this paper, the solubility enhancement technology for accomplishing tableting chemicals, replenishment reduction technology with the use of the new developing agent, packaging materials and system designing technology including a chemical mixer are mainly described.

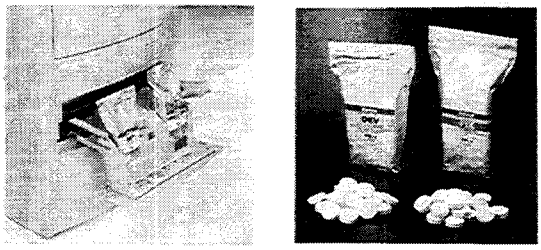

Fig1. TC Processing System

2. Outline of the System

In order to solve substantially problems of the conventional liquid processing chemical system, it is effective to supply the processing chemicals in dried form. The conventional powder or granular processing chemicals have been hardly spread in the Japanese medical market because a dust problem has been caused at the preparation work of solutions and disposal of packaging materials. In the present system, the dust problem has been solved by tableting the processing chemicals and the weight of the processing chemical kit has been reduced to 1/5 as compared to the conventional one. In addition, the volume of solution wastes has been reduced to 2/3 by practicing erythorbic acid as a replacement of hydroquinone.

In addition, packaging materials which are easily crushed and burned up have been developed and the volume of the packaging material wastes has been remarkably reduced to about 1/20 as compared to the liquid bottle wastes.

	Tableted Chemicals (TCX-201 System)	Liquid Chemicals (SRX-201 System)
Weight of Chemical Kit (Kg)	1.4	7
Volume of Chemical Wastes (L/month)	34	53
Volume of Packaging Wastes (L/month)	2.5	50

Processing volume; 250 sheets of 10×12in film/week

Table 1. Advantages of TC Processing System

3. Tableting Technology

The basic properties required for tableting processing chemicals are as follows.

(1) High hardness without forming powder
(2) Good solubility

(3) Good shelf life for a long period of time

In the present system, the requirements mentioned above have been fulfilled by the application[1),2)] of the tableting technology developed for the color minilab and by the development of the solubility enhancing technology and shelf life improving technology specifically for the medical processing chemicals.

3.1 Technology for Preventing Powder Formation from Tablet

When components of the processing chemical are merely tableted, no sufficient hardness is generally obtained. Accordingly, a problem such as the formation of powder during transportation, etc. is not solved. In order to reduce the powder formation to a negligible level as compared to the powder chemical or granular chemical, the hardness of the tablet is increased by the addition of a binder so that components are firmly united. As the binder, any of highly water-soluble sugaralcohols is utilized which results in no adverse effect on properties of processing solutions and causes no deposit in the processing solution. Further, the tableted processing chemical causing no formation of powder due to the increase in the hardness has been realized by the following process. Raw materials are grained so that each grain diameter is the same, mixed and grained, and the resulting grains are then tableted .

3.2 Technology for Improving Shelf Life of Tablets

A processing chemical contains components which react each other. In a developer, erythorbic acid employed as a developing agent undergoes acid decomposition in the presence of a small amount of water when contacted with an alkali. Furthermore, in a fixer, a thiosulfate salt employed as a fixing agent is sulfurized to form insoluble sulfur during the storage under the contact with an acidic aluminum salt employed as a hardening agent. In order to solve the problems, for the developer, a developing agent and an alkali are independently grained, tableted and then put into a packaging bag together and sealed. Furthermore, for the fixer, a long shelf life is secured in such a way that a fixing agent and an acidic compound are independently grained, tableted and then put into a packaging bag together. In addition, the long shelf life of the fixer is also secured by adjusting the water content in an acidic part comprising an aluminum salt which works as a fixing hardening agent.

3.3 Technology for Improving Solubility of Tablets

In the tableted processing chemical system for the minilab, tablets are directly put into processing tanks. However, in the present system, as the processing amount of films is large, the required amount of tablets becomes large. As a result, the direct supply of tablets are not practical. Thus, a method has been employed wherein one kit of tablets is previously dissolved using a mixer built in an automatic processor and is supplied to a processing tank as a replenisher. On account of this, when processing continuously film, the short dissolving time is required so that the supply of the replenisher is not stopped. For the developer, the developing agent part which is independently tableted for the improvement in the shelf life has poor solubility. The poor solubility is improved utilizing a technology for increasing the rate of crumbling tablets at the dissolution. Specifically, a metabisulfite salt employed as an acidic compound is added to the part comprising a developing agent which holds a rate determining step at dissolution. At the dissolution, the salt reacts with carbonic acid ions contained in the alkali part to induce the generation of carbon dioxide which crumbles the tablet from the surface. Thus, the rate of the dissolution is remarkably enhanced by diffusing the tablet in a granular form having a large surface area into the solution (Fig. 2).

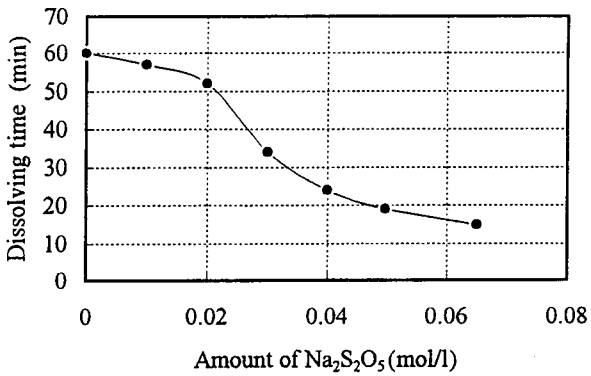

Fig 2.Dissolving time of tableted developer

In addition, in processing the medical film, the fixer generally comprises an acidic hardening agent. A thiosulfate salt employed as a fixing agent has a problem such that insoluble sulfur is formed at a low pH. The conventional one-liquid type concentrated kits are prepared so that no localized pH variation occurs. Further, in the conventional fixer powder or fixer granular, the hardening agent has been supplied separately. In the present system, the fixing agent and the aluminum compound employed as an acidic hardening agent are tableted independently and during the dissolution, no contact of both agents at high concentration is arranged. Thus, a single solid fixer comprising a hardening agent has been successfully developed which prevents the localized decrease in pH near the fixing agent so as to form no deposition of sulfur.

4. Practical Use of New Developing Agent

When the replenishment rate of a developer is reduced, development activity is lowered due to the accumulation of development restrainer (Br^-, antifoggant etc. dissolved out from films) and accumulation of development exhausting materials. Furthermore, when a developer stays in a

developing tank for a long time, it is exhausted due to aerial oxidation. Specially for the customers who process a small amount of film, it is hard to maintain the consistent quality for a long time. Furthermore, the concentration of silver ions which are dissolved into a developing solution increases and as a result, stain is caused due to the presence of silver sludge formed during a long period of running. Furthermore, conventionally employed hydroquinone as a developing agent has caused problems such that a large amount of a preserving agent (sulfite salt) is required; the solution wastes result in a large environmental load due to high BOD and COD and colored stain is caused due to oxidation. In order to solve the problems, the present system has replaced conventionally employed hydroquinone with erythorbic acid as a developing agent and the consistent processing properties have been accomplished under the low replenishment rate.

4.1 Technology for Improving Preserving Properties

Since erythorbic acid has a stronger reducing power than hydroquinone, deterioration due to aerial oxidation is much improved by setting the pH at 9.8 which is much lower than 10.4 of the hydroquinone developer. Thus, after a long period of running by a 2/3 replenishment rate as compared to the conventional, the stable quality is realized by maintaining the amount of the remaining developing agent at 95 percent or more (Fig. 3). At the same time, the concentration of a sulfite salt can be reduced to 1/4 as compared to the hydroquinone developer and together with the reduction in the replenishment, the COD load is remarkably reduced.

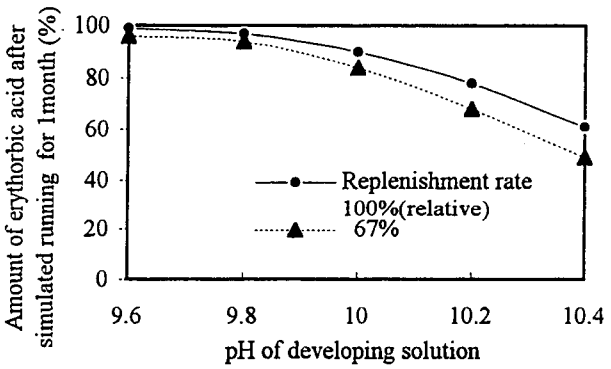

Fig 3. pH Dependence on aerial oxidation of developer

4.2 Technology for Improving Stability of Development Activity

Since erythorbic acid, when reducing silver halides, releases a larger amount of H^+ ions than hydroquinone[3], the decrease in pH is large due to process fatigue followed by the large decrease in development activity. The decrease in the development activity is also caused by the decrease in a pH of a gelatin layer during development. To the developing solution comprising erythorbic acid as a developing agent, high buffering capability for pH is given by employing a large amount of a carbonate salt and the decrease in pH due to the process fatigue is prevented. At the low replenishment rate such as 220 cc/m^2, the stable development activity is maintained and a rapid processing of dry to dry 60 seconds is practiced (Figs. 4).

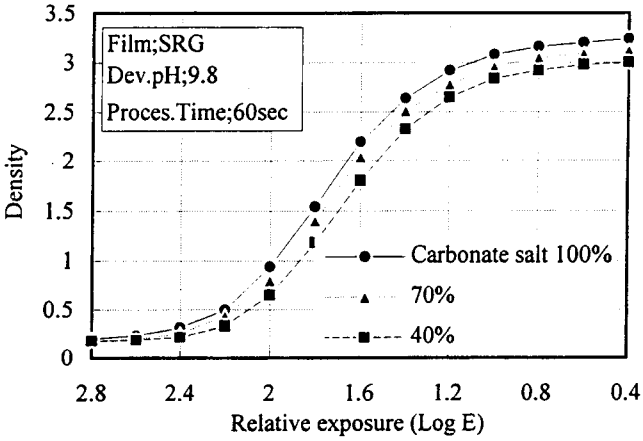

Fig 4. Dependence of development activity on carbonate salt content

5. Design of Packaging Materials

Improvement in plastic bottles for liquid processing chemicals has been strongly requested because of the bulkiness at the disposal. For packaging the tableted processing chemicals, are utilized supports made of card bord and barrier materials made of soft packaging materials which are designed so as to be folded. Thus, it has been realized that the volume of packaging material wastes is greatly reduced to about 1/20 as compared to the conventional.

Functions required for packaging materials employed for processing chemicals include moisture resistance (against pin hole) and secured unsealing. The moisture resistance has been accomplished utilizing an aluminum foil and a nylon layer. In addition, in order to prevent drop of tablets when unsealed, a noble layer structure of a barrier bag is designed so that it can be torn in a straight line. In accordance with the decrease in tear strength, requirements are fulfilled by arranging ONY and OPP layers in order to give a straight tearing properties in the lateral direction (Fig. 5).

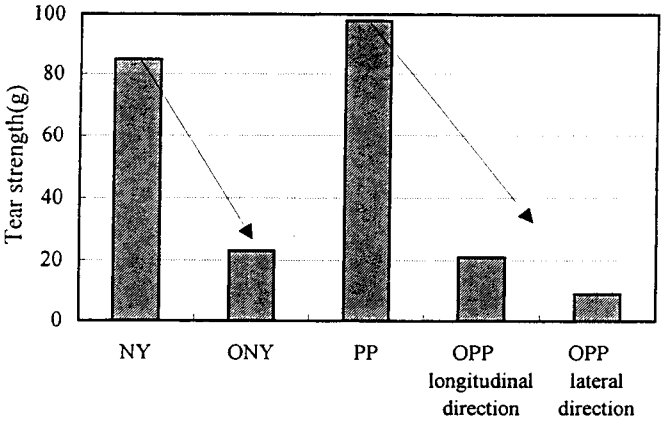

Fig 5. Tear strength of ONY and OPP layers

6. Design of Chemical Mixer Built in Automatic Processor

In order to accomplish the rapid dissolution of the tableted processing chemicals, a simple dissolving mechanism with stirring has been developed which depends on a high flow rate circulation method having a slanted filter. Fig. 6 shows the relation between the circulation flow rate and the dissolution time. In the present system, the dissolution is shortened employing the optimum flow rate of 40 cm/sec or more. Furthermore, as shown in Fig. 7, the lower part A of the slanted filter in a dissolving tank is a high flow rate portion and fed tablets are dropped subsequently by own weight while tablets are being dissolved and supplied to the high flow rate portion.

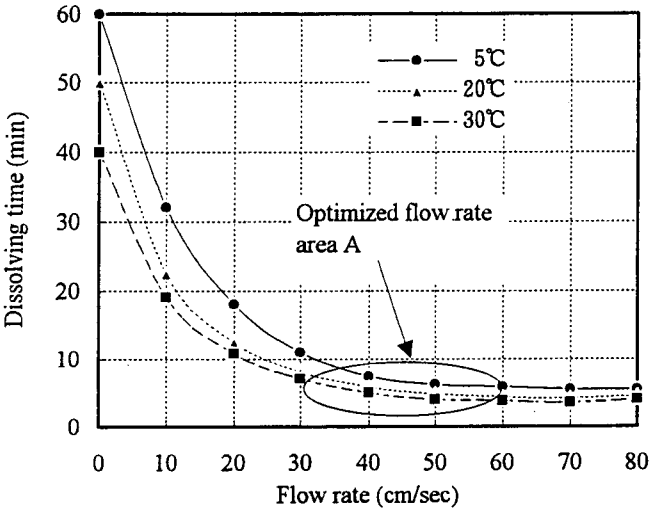

Fig 6. Relation between the flow rate and the dissolving time

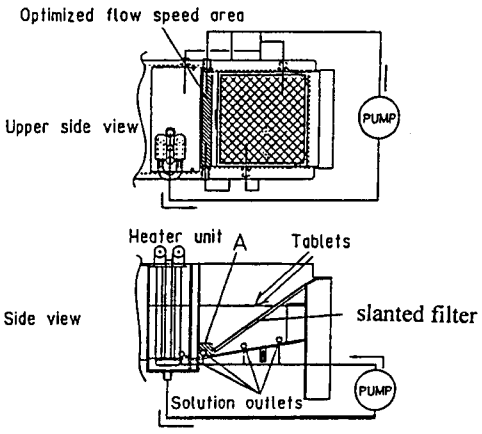

Fig 7.Dissolver tank of the chemical mixer

7. Summary

The TC Processing is the first tableted processing chemical system in the medical field. It is a epoch-making system which enables customers to perform a light, simple and clean processing solution preparing work. We would like to develop it as a new generation processing system and broaden our contribution to the medical service.

8. References

1. Moeko Hagiwara and Kenji Ishida, Proceedings of Annual Meeting of the Japan Photographic Society, A16 (1996).
2. Sigeharu Koboshi, Journal of the Japan Photographic Society, 58(6) 541 (1995).
3. Klaus Niemela, Journal of Chromatography , 399 235-243 (1987).