SOLAGEN: PROCESS IMPROVEMENT IN THE MANUFACTURE OF GELATIN

William Bolten, gelatin plant superintendent, was sitting in his Kodak Park office in June 1982 preparing for a meeting to be held the next day. Dr. Brian Woolsley, director of the chemistry division, Dr. George Searle, director of the manufacturing services organization, and Bolten had to answer the question of whether or not Kodak should proceed with the construction of a production plant for Solagen, a new gelatin manufacturing process. The estimated cost for the plant was $46 million, in addition to the more than $3 million already spent on Solagen R&D costs and pilot plant expenses.

The R&D project, code-named Solagen, was spearheaded by Mr. Frederick Carson, who was looking for ways to improve the overall gelatin-making process. Gelatin was a critical element in Carson's overall strategic plan (Exhibit 1).

In some ways, Bolten felt it was absolutely critical that Kodak make the investment in order to keep pace with the cost and quality levels dictated by competition. However, Bolten also felt there were reasons to seriously question if now was the right time to move ahead with a new and still unproven technology to replace the process now in use.

Gelatin was a key ingredient in the manufacture of high-quality film and paper. It was therefore essential to daily operations throughout Kodak as it was used in some 980 different types of film, and some 270 kinds of photographic paper. Because of the clarity of images demanded in photos, gelatin used as a coating in film making had to be purer, and more transparent, than the gelatin that goes into familiar food products, such as Jell-o. The basic process used for making gelatin was more than 150 years old, and had been largely uninfluenced by new technologies during that time.

Solagen's Benefits

There were a number of benefits promised with the new Solagen process. The most notable was reducing the length of the liming step in

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This case was prepared by Research Assistant Brian DeLacey, under the supervision of Assistant Professor Dorothy A. Leonard-Barton, as a basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

the process (Exhibit 2) from the present range of 30 to 80 days, to a mere 48 hours. The Solagen process would also increase the yield of this step from its present low of 40% to at least 80%. There were substantial inventory and material handling benefits associated with the reduced processing time and increased yield. Additionally, R&D promised improvements in picture quality (clearer, crisper pictures) and film manufacturability (stronger emulsion resulting from the new gelatin process would simplify the coating of the gelatin emulsion onto film base). Exhibits 3 and 4 outline the steps in film making.

Solagen's Drawbacks

Solagen also had drawbacks. Solagen was a process made up of new technologies. Some parts of the process were radically new and largely unproven. While statistics from testing had been encouraging, they weren't conclusive. Additionally, Solagen was expensive: it necessitated new equipment and a new plant; whereas the old plant was fully depreciated and paid for. Finally, since the main difference in the roughly 400 different types of film-making emulsion Kodak used depended on the crystal sizes formed and suspended in gelatin, any changes to the gelatin-making process could have wide-ranging, long-term effects on Kodak's films and photographic papers.

Film Making: Art and Science

Another important issue had been on Bolten's mind since he first stepped into the old and, from outward appearances, neglected gelatin building. From the standpoint of gaining control over the manufacturing operation, it seemed desirable to move the "art" of gelatin making closer to a "science." In the early 1970s, a general manager at Kodak Park wrote:

> There is a large quotient of witchcraft in successful gelatin making. You have to forget much of everything else you have learned about modern principles of manufacturing. There is no better or worse in gelatin making. A batch either works or doesn't work with a given film or paper and there are no reliable techniques for telling in advance which is which.

Since that time, additional knowledge had been gained about useful techniques related to the overall gelatin-making process. But was there enough formal knowledge about the existing process to help make the giant leap from "witchcraft" to the precision required for Solagen's success?

One of the early cost/benefit analyses is shown in Exhibit 5.

Company History

George Eastman was born July 12, 1854 in New York. When he was 14, poverty forced Eastman to leave school. Vowing to relieve the family's financial distress he worked his way from $3 per week at an insurance company to a better paying job as a junior clerk at Rochester Savings Bank. At the age of 24 he decided on a much-needed vacation to Santo Domingo. An engineer who worked in the basement of the bank told him to make a photographic record of his trip. This chance suggestion introduced George Eastman to photography. Seven years later he started his photography business. The word "Kodak" was first registered as a trademark in 1888.[1]

Sales had grown to $4.6 billion in 1974 and to $10.8 billion in 1982. Film, paper, and chemicals are produced at Eastman Kodak's largest manufacturing plant, the Kodak Park Division in Rochester, New York. Situated on some 2,000 acres, Kodak Park stretches more than three miles, and includes nearly 200 major buildings. By 1982, more than 30,000 people worked there.

The film, photographic paper, and more than 900 chemical formulations used in their processing, are sold to the printing and newspaper industries, the motion picture and television industries, the aerospace program, government, hospitals, schools, libraries, professional photographers and photofinishers, and amateur picturetakers.

The Existing Process of Making Gelatin

As shown in Exhibit 2, the process of making gelatin was a time-consuming process. One of the critical steps, liming, was subject to a number of elements beyond the control of people in the gelatin plant. Temperature and humidity influenced the rate at which the liming reaction took place in the open wooden and stainless steel vats. The composition of the lime varied depending on the source. The quality and composition of the bone that came from a number of domestic sources and India varied greatly. An experienced gelatin maker pointed out the difficulty of getting a predictable quality raw material by saying, "You don't know where the cow has been, what it has eaten, what environment it's been exposed to, so it's difficult to know what quality bone you are getting. It's not like something synthetic where you know the exact composition."

Randall Sudbury, a foreman of the staff in the aciduation and liming steps in one of Kodak's gelatin plants, exemplified the kinds of skills required in this process. Sudbury had been with Kodak for 22 years. For 13 years, he had been deciding when the liming step was complete and the limed ossein could be sent to the cooking step. Sudbury also instructed the three shifts working in the liming area what corrective actions to take if the liming step was proceeding too quickly or too slowly. Sudbury said he tested the limed ossein by sight, feel, and smell.

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[1] O.N. Solbert, George Eastman: A Brief Biography, George Eastman House, Inc., 1985. There has been varied speculation on how the name Kodak was originated. But the simple truth is George Eastman just made it up. In his most succinct explanation of how he devised the name, he said: "The letter 'K' had been a favorite of mine--it seems a strong, incisive sort of letter...It became a question of trying out a great number of combinations of letters that made words starting and ending with the letter 'K.' The word 'Kodak' is the result."

First, Sudbury could tell if more lime was needed, for instance, simply by looking at the color of the ossein in the pit. Second, he would penetrate the surface of a fistful of ossein with his fingernail, always applying the same pressure. The way the gelatin peeled back off his fingernail indicated whether the liming step was complete. This was called the "finger test" and was confirmed by the "squeeze test." For the squeeze test, Sudbury took a fistful of limed ossein, rolled it in his hand and squeezed it, applying the usual amount of pressure, to feel the texture and firmness as another test whether the liming step was complete. In the third and final test, Sudbury would smell a fistful of limed ossein. Based upon the amount of chlorine he could smell, Sudbury would confirm or invalidate his previous tests.

Sudbury had learned his job from the previous person who held it, who in turn had learned what differentiated good from bad limed ossein from the person who performed the tests before him. It was a craft that had been passed from generation to generation of worker, and a job that not everyone wanted. Sudbury said, "At the time I started, anyone who wanted the job could have had it. All you had to do was stick your hand in the liming pit. If you had sensitive skin you were in real trouble, because the lime irritates it. In fact, I've had good luck; I still have my skin."

Sudbury sampled one pit in each lot every 6 or 7 days, taking a total of 52 samples. Each lot represented about 250,000 pounds of ossein. Sudbury could usually tell after taking two samples whether or not the lot would be good. According to Sudbury, a lot rarely turned out bad, and if it did it was because of a mistake on the part of someone in the department, for instance forgetting to add enough lime.

After the liming step came the cooking step, and the effluent of the cooking step was dried and packaged as gelatin.

The dried gelatin was stored in containers sorted according to the characteristics of each batch. Gelatin from the various batches was then blended as needed to meet the specifications of the different customers. For instance, the top 15-20% in quality was reserved for use in making very sensitive film, since this gelatin was chemically nonreactive. For paper (the largest consumer of gelatin), color characteristics (as measured by the yellow density) were more important than chemical properties.

<u>Frederick Carson's Proposal for a New Gelatin-Making Process</u>

Carson joined the Polymer Development Laboratory in 1968. In 1977, he became head of the Chemical Processing and Engineering Laboratory, a department within the Research and Development area, and reported to Dr. Brian Woolsley. In planning for his new position, Carson identified a number (<u>Exhibit 1</u>) of key areas he wanted to work on. At the top of his list was gelatin, because he felt no other process or ingredient was so critical and less understood at Kodak.

The lack of process-related research efforts in the past was due to a lack of technology and methods to measure gelatin characteristics on a fundamental level, and a feeling that a synthetic substitute for gelatin was just around the corner.

Carson initially wondered if they should replace gelatin with a synthetic polymer (i.e., a petroleum-derived material). With the United States in the middle of an oil crisis, however, Carson decided it was best to continue to use renewable resources (bones, hide trimmings) as product ingredients but look for ways to improve the existing gelatin manufacturing process.

Carson commented on how his top priority project got underway:

> We had never interacted with the gelatin people. First, we had never met these people. Second, we were seen as the ivory tower. I asked them to let us take at least a one-year crack at seeking improvements in the gelatin-making process. If results were positive after a year, then we could continue on. I sent a proposal outlining this to the Gelatin Team Leader Nick Thompson who forwarded it to Wayne LaFrance, gelatin plant superintendent at that time. In it I pointed out that making gelatin was such a "black art" that we needed to improve our understanding of gelatin and the way in which it was manufactured.

While the proposal met with no active opposition initially, the plant showed little interest either. Comments on the proposal were not substantive.

Since Carson was certain that this was a key area to work on he decided to start researching gelatin anyway. Funded by the research division, Carson had broad discretion for the use of research funds, so the gelatin plant's initial lack of enthusiasm wasn't a significant hurdle to overcome.

Carson's next step was to bring in full-time help to work on gelatin. "We hired Peter Wolanski in 1977, from Princeton, with a Ph.D. in chemical engineering," Carson said. "He started working on the basic understanding of the gelatin process since so little was known about it. Peter's research was top notch and greatly helped in an understanding of both the aciduation process as well as the liming process."

Carson soon increased the effort on gelatin by also assigning Keith Morrow to work on the process. "Keith has a master's in chemical engineering and is an excellent go-getter with the talent to look at a process and pull together all the loose ends."

Over the next several months, Wolanski and Morrow came up with a prototype of a rapid gelatin-making process. Their bench-scale prototype process produced in 48 hours the equivalent of the six-month liming operation. The proposed process involved adding several chemicals to the raw materials in a reactor, instead of a liming pit, and accelerating the reaction. The temperature and other reaction conditions could be controlled and the chemicals served as a catalyst to carry out the necessary reaction. This new process came to be known as Solagen, which was short for solubilized collagen. (See Exhibit 6 for a comparison of the flows associated with the new and old processes.)

Wolanski and Morrow felt they had proven that the new process was technically feasible and any remaining questions could be resolved as part of larger scale testing to be carried out by the gelatin plant staff working in conjunction with the Chemical Processing and Engineering Lab. Wolanski moved on to other projects while Morrow continued to work full time on Solagen.

Planning the Project

The CEO of Kodak, Alex Blanchard, had heard about the Solagen project early in its inception, from an assistant who had visited the R&D labs and saw the work Carson's group was doing. Very enthusiastic about the potential for this new process, Blanchard made it known that he felt this was the direction in which Kodak development should be heading. From time to time, the R&D group would visit Blanchard's office and make presentations. After several of these visits, a meeting was scheduled in August 1980 (refer to the meeting agenda shown in Exhibit 7), including representatives from the gelatin plant.

One of the results of this meeting was the project schedule shown in Exhibit 8. This was viewed as the formal kickoff for the project, with the people to be involved in the project shown in Exhibit 9.

William Bolten, Gelatin Plant Superintendent

In 1980, William Bolten was sent to the Gelatin Division initially as an assistant superintendent, with responsibility to oversee development of the Solagen project. Shortly after, in 1981, Bolten was promoted to superintendent to fill the spot vacated by retiring Wayne LaFrance, who had worked in the Gelatin Division for 33 years, 17 of them as superintendent. Bolten had five years' experience as assistant superintendent in the Synthetic Chemicals manufacturing plant, a bachelor's degree in chemical engineering, and an MBA from Rochester Institute of Technology. Several project members considered Bolten to be on the fast track at Kodak; he was young for an assistant superintendent and highly regarded for what he accomplished in his previous position.

Bolten found out several things about the Gelatin Division his first few days on the job. It was staffed by many people who had been there 20 or more years. As a result, Bolten got the impression that the staff had lots of depth but not a lot of breadth of skills: they were very good at what they did, but not very good at introducing changes into their environment. The plant itself was old and in need of repair.

After a few weeks on the job, Bolten began to feel that, for him at least, this project was a no-win situation. Management, all the way up to the CEO, was already convinced that the new process was a success. If Bolten managed the implementation successfully, his efforts wouldn't be perceived as any great accomplishment. On the other hand, Dan Lee, the other assistant superintendent, said right off the bat that Solagen just wouldn't work. Lee had worked in the gelatin plant for 28 years, had earned the respect of every technician and staff member in the plant, and was openly opposed to the Solagen project.

When Brian Woolsley called to schedule the next day's meeting, Bolten was looking at several reports regarding the Solagen program and reviewing his notes from Thursday's weekly meeting of the Solagen Steering Committee. The goals of the Solagen process were to develop a single, continuous, process to produce a gelatin with a yellow density in the range of .010 to .011, and a yield of at least 80%. Since most of the output of the present process ranged from .013 to .014, these tighter color specifications would constitute a significant improvement. The increased quality of prints made with the new gelatin would be very noticeable to customers, and result in a competitive advantage for Kodak's paper products.

One report Bolten had was a checklist of tests that five months before the Solagen Steering Committee had laid out as a set of objectives to be accomplished over the next six months. If the objectives were met, then Bolten would support a request for funds to build a new gelatin manufacturing facility. Bolten felt the testing on the quality and yield of the new gelatin still wasn't providing statistically significant results within the time frames originally established, although significant progress had been made and there was the promise of more to follow.

Another report from marketing showed that demand for gelatin would be less than had been originally projected two years ago. Thus the potential cost savings to be realized through the new process were no longer as great an incentive; there was no longer a near-term need to add capacity to the existing gelatin facility.

The last report, from the development lab, pointed out that there were several technical questions that could only be adequately addressed with further expensive testing on production-size equipment.

One final point had been bothering Bolten for some time. The original proposal from R&D argued that the quality improvements would be significant, and testing to date did look promising on this issue, but quality improvements were hard to quantify and didn't fit neatly into any of the established corporate methods for capital project evaluation.

Bolten felt the company had already benefited greatly from the Solagen project in two major ways:

1) discussion and prototyping of the new process had pushed the old process to higher levels of productivity, quality, and yield.

2) a great deal had been learned about gelatin over the last two years, which would certainly leave Kodak better prepared for the future.

The Gelatin Plant's Response to the Prototype Process

There was a feeling among the long-term employees in the gelatin plant that it took ten years or more with the gelatin-making process to really understand it. Carson's group clearly didn't have much experience working with gelatin, although they were very qualified technically. Antony Capicello was one of the few people in the plant in favor of looking into the process proposed by Frederick Carson. Shortly after bench-scale testing began, Capicello was called away on a six-month assignment.

He returned to the gelatin plant the same day his boss, William Bolten, started as the plant's assistant superintendent. Capicello's job was primarily process optimization, but he also had responsibility for scheduling gelatin production, budgeting, personnel, the small in-plant development lab, and was designated as the interface between the R&D area and the gelatin plant. He wasn't ready to believe the existing process couldn't be improved upon. Furthermore, having worked on a successful project with Carson several years before, in another division, he wanted to give Carson's proposal a chance.

He was aware that his position was not a popular one. Everyone knew that a similar process, attempted by a well-known European supplier of gelatin, had failed. By the time that company had given up on the process, they were nearly ruined financially. Why should Kodak switch to a process already tried and abandoned by others?

Furthermore, the current gelatin-making process was much more flexible. In the traditional batch process, gelatin makers had a production window of up to five days during which the limed ossein could be used. The continuous process used on the Solagen method required precise timing. Referring to the necessity to follow the reverse osmosis step immediately with acid quenching, one veteran gelatin maker observed: "If you don't hit that baby just right, you're in real trouble."

One senior level manager at Kodak with extensive gelatin-making experience commented on his philosophy about managing this kind of operation for quality:

> It takes people close to a job to really know what a quality job is. For the longest time the assistant superintendents would make all the decisions regarding when the limed ossein was ready. But later this decision making was put in the hands of the foreman, who was closer to the liming process. You need to have people close to the job making decisions about what they are doing; this keeps them committed to doing a quality job. I'd like to see every person out there an artisan, a craftsperson, a person interested in what they are doing. Sometimes introducing a new technology will put technology between the person and the craft, and people can become less committed to quality as a result.

The Pilot Plant

By the summer of 1980, R&D felt that enough bench-scale testing had been done. They proposed moving to larger scale equipment. Gelatin strength, viscosity, and color had all been tested in liter quantities. The options available were: 1) buy larger scale equipment for R&D; 2) build a pilot plant in the Kodak Park gelatin-manufacturing plant; 3) build a pilot plant in another Kodak gelatin-manufacturing plant located 500 miles away from Kodak Park.

Dr. Searle and William Bolten decided that it was best to start the pilot phase in the Kodak Park gelatin plant, ruling out option 1 because some of the expensive equipment was already available in the gelatin plant. While option 3 was attractive because of previous successes in introducing changes to the gelatin-making process at the distant gelatin-manufacturing plant, it was eventually ruled out. The primary reason was distance from the main R&D laboratories.

A joint development effort between R&D and the Kodak Park gelatin plant was initiated. Keith Morrow, two technicians from the gelatin plant, Frederick Carson, Antony Capicello, and William Bolten made up the project team for the pilot plant in the early stages.

Funding for the pilot plant was approved quickly. Capicello explained how the project was funded.

> For the operating expenses (such as labor, raw materials, and testing) we had an Experimental Work Order (EWO), which was pretty much a blank check on funds that we could spend at our discretion. Since 1977 we spent about $2.7 million in funds from the EWO. For capital equipment (such as pumps, tanks, etc.), we had to submit a SER (Special Expenditures Request) to Kodak Park management. We spent about $300,000 on building the pilot plant, after approval from Kodak Park management.

A Technician's Point of View

"I would say that I have the most experience of anyone who has worked on Solagen," said George Levitt, a technician with six years of experience in the gelatin plant before starting to run the Solagen pilot plant. "I have averaged probably 12 hours per day on just Solagen for about a year and a half. At the same time I was going to school. My son was real small at the time, and I can remember many a night when I was holding his bottle in one hand feeding him, while holding Solagen data in the other.

"Gelatin is very, very complex. It's not an easy thing to do. It isn't like adding A and B and coming out with C. It's very, very temperamental. It's not easy to work with. Unless you know the ins and outs, it's a bear."

Levitt continued, "With two full-time projects going, I have worked an average of 65 to 70 hours a week, sometimes as long as 32 hours at a stretch. I am the only one in the building who really knows what's going on with Solagen. The only other person I know who has worked these kinds of hours also works on Solagen. In fact, he and I sometimes have a contest to see who can stay awake the longest--I hold the record at 37 hours."

Levitt worked on carrying out the testing under the direction of his boss, Antony Capicello, along with Robert Stone, a development engineer from the Manufacturing Services Organization.

Toward the end of the pilot plant phase Levitt felt that the output could reach the .010 to .011 yellow density level, but only if another step were added to the Solagen process. His supporting evidence was drawn from a limited amount of testing; therefore, the benefit of an additional step was more of a hypothesis than a conclusion. Since the composition of the raw materials going into the process had the greatest impact on the quality and nature of gelatin output, his suggested change would have to be tested across a large number of different batches before anyone could be certain the results were not due to the characteristics of a few particular batches of raw stock. Furthermore, the gelatin output from the current Solagen method had already been extensively tested by the film and paper divisions. Adding in one more step would require an enormous amount of retesting and add much uncertainty back into the process. The Solagen Steering Committee decided against pursuing the idea further.

<u>A Process Engineer Comments on the Project's Progress</u>

Keith Morrow was the researcher who had worked on the project the longest. He had several insights to offer on the project's development to date.

> If something looks exciting, you want to do it right away. Oftentimes, however, it is not a matter of putting more people on the project and gang-tackling it. Sometimes it simply takes more time. My impression is that the project has just gone too fast from the start.
>
> We had process objectives we were trying to meet, we had a specification on the product to meet, and we had a facility we wanted to build. All three of those require different kinds of information. The process people want to tinker to see what the process can do; the product people want you to demonstrate that the product is very reproducible, so they don't want you to tinker around with the process; the design people are looking to do major things, like trying out a completely new piece of equipment in the plant.
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> All those areas are pulling on each other to get information. Of course, the design person doesn't want to become the one who built the multimillion dollar plant that

> didn't work; the product person wants 100% certainty that you can consistently make the product per specification; the process person, me, wants the maximum amount of latitude in tinkering with the process in order to reach its optimal levels. All that is compounded by a compressed time frame.
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> I'm sure every technical person will tell you they never had enough time to work on all the things they wanted to. But the fact is, one of the biggest difficulties on this project has been the time pressure we have been under.

Phototesting the New Gelatin

According to Tom Fritsch, representative for the Film Division (a major consumer of output from the gelatin plant):

> My job was to take the gelatin being produced by R&D and the pilot plant, and run tests on various films and photographic paper to look for significant differences from the existing gelatin. This type of testing was standard procedure for new products or for any process changes being introduced. Gelatin plays such a unique role in the behavior of photographic material, that if you use a new gelatin you have to go back and reformulate the film from the ground up. Because of the impact this would have on the manufacturing areas, some of the plant managers weren't particularly enthusiastic about the Solagen project.
>
> It became clear that the new gelatin had some unique physical properties different from the existing gelatin. We had determined, however, that there were no exceptionally good or bad properties and the Solagen process gelatin had acceptable qualities for use in film manufacturing.

Solagen at a Crossroad

Several recent developments had begun to influence Solagen's momentum just as the Special Expenditures Request (SER) for $46 million was being considered for approval:

1) A revised financial analysis was prepared taking into account a drop in the projected demand for gelatin. The corporate measure for project evaluation was Cash Flow Rate of Return (CFRR) which weighed heavily the fact that the old machinery and equipment in the gelatin plant had already been paid for and depreciated. The CFRR now worked out better sticking with the old equipment and old process rather than investing in the new process.

2) Original projections put utilization of current gelatin capacity at 115% to 120% by 1983, whereas actual data showed present utilization about 85%. As a result, the potential total dollar cost savings from yield

improvement were significantly less than originally anticipated and there was no longer a need to build a new plant to meet increased capacity requirements; however, there would still be a need for a new plant to house the Solagen process because it was so different from the existing gelatin-manufacturing process.

3) There were several technical aspects still in question: there existed too few standard specifications on gelatin for comparing the "new" gelatin to the "old" gelatin, so it was difficult to judge how much better or worse the new gelatin was. The yellow density of the new process was approximately the same as that output by the old process. Moreover, the yield figures seemed to be closer to 60% than the 80% originally targeted, although still better than the 40% yield of the existing gelatin-making process. (Note: Since portions of the testing were done on expensive equipment in different labs throughout Kodak Park, it was unclear exactly how much yield was being lost due to limitations of the new process and how much was being lost simply due to measurement error from samples being trucked around Kodak Park. This became known as the "transportation problem." Another question asked often was "Can you assume the yield from each separate unit test will give a meaningful overall yield in a continuous process when everything is tied together?")

4) There still was no established procedure for placing a financial value on the improved quality that would result from decreased gelatin variability. There was no way to incorporate this factor into Kodak Park's economic analysis.

5) Finally, the changing market environment was an important factor to consider in planning Kodak's future activities. Heightened competition from Japanese film manufacturers was challenging Kodak in the areas of quality and cost.

Kodak prided itself on its position among the elite of R&D spenders (Exhibit 10), making it possible to undertake projects such as Solagen. But the strong and steadily increasing sales of the past (Exhibit 11) were less certain in the future, making it more difficult to justify R&D dollars than ever before.

Exhibit 1

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

Research Proposals for the Chemical Process Engineering Lab[a]

Based upon the ... input received as a result of interviews with a number of people within and outside the company, I would like to recommend that the CPEL begin active research programs in the following areas:

1. Gelatin Manufacture

Gelatin is a key component of all our photographic products and the company uses 12 million pounds of it every year. Practically every film and paper product made by the company depends upon the availability of gelatin of known quality.

2. Large-Scale Separation Techniques

A large portion of the trouble and expense in making new chemicals at Eastman Kodak lies in the separation and purification steps. New fields that the company will be entering in the future will put even more stringent demands upon the purity of the chemicals needed, and the tried and true methods of repeated crystallization of precipitation will be found to be impractical and inefficient in terms of energy and materials needed.

3. Reaction Control

As the chemicals required for the company get more and more sophisticated, the control of the reactions to make them will become more and more critical. Mathematical modeling of the process can lead to insights regarding the parameters which are crucial to ensuring product quality and can be used in conjunction with microprocessors to carry out the control in an optimum manner.

Overall, in the process research capacity, we must communicate very closely with the inventor of a chemical, the user of the product, the Facilities Organization, the development groups in Kodak Park, the engineering groups and the outside community in academia and other companies.

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[a]Excerpts from a Technical Report, October 13, 1977, Opportunities in Chemical Process Engineering, Fred Carson, Kodak Research Laboratories.

KODAK, Existing Gelatin Manufacturing Process

Exhibit 2

Length of time to process (days)	Step	Description
1	Crushed Bone	Crushed animal bone was received in trainloads, from various suppliers in the United States and India.
5 - 7	Aciduation	Crushed bone was mixed in large wooden or stainless steel vats, and mixed with a dilute Hydrochloric Acid solution; several hundred vats were active at any given time processing thousands of pounds of bones. Grease and unwanted minerals were removed from the bone. This step took from 5 to 7 days. The output was called Ossein, or demineralized bone.
	Ossein	
30 - 80	Liming	The Ossein was fed, via ducts, directly into liming pits - either holes in the ground or stainless steel vats. Two people monitored the vats to insure that the Ossein reacted in the lime at the right rate. If the reaction moved too quickly or slowly, the vats were drained, the lime washed off, and a new amount of lime added. Duration of this step depended upon composition of the ossein, humidity, temperature, and composition of the lime. The output was called Limed Ossein.
	Limed Ossein	Limed Ossein was ready in 30 to 80 days, 50 to 60 days being the usual period of time. The "squeeze test" and "finger test" (as described on pages 3-4 of the case) were used to determine when the Limed Ossein was ready. The Limed Ossein had to be used in the 5-6 day period after passing the "squeeze test" or it would spoil.
1/2	Washing	After liming, the Limed Ossein was washed and fed via ducts to the cooking facility
	Washed Limed Ossein	
5 - 7	Cooking	The washed Limed Ossein was placed in vats, water was added, and brought to a boil. The water reacted with the purified collagen in the bone to give off an effluent called gelatin. Six to seven cooks took place. After each cook the vats were drained of the effluent, steam cleaned, refilled with water, and reheated. After the final cook, the remaining bone was disposed of, all the useful collagen having been used in the previous cooks.
	Gelatine Effluent	The output from the cooking step was liquid gelatin.
1	Drying, Packaging, & Storage	The final step involved drying gelatin on a 200 foot conveyor before packaging in four foot high barrels used for storage prior to being shipped to film/paper manufacturing.
1/2	Blending & Shipping	When an order for gelatin was received from a film or paper manufacturing plant, a blend of gelatin batches, which varied in composition, was prepared from the barrels of dried gelatin in inventory to meet the requirements of the film/paper to be produced.

Exhibit 3

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

Major Steps in the Manufacture of Film

1. Cotton linters and pure wood pulp are dissolved to form "dope."

2. The dope is filtered and poured onto huge, slowly turning wheels. It is then dried to form a plastic cellulose acetate, which becomes the film base.

3. Silver, the essential light-sensitive material, is dissolved in nitric acid. The resulting silver nitrate is crystallized, dried, stored in barrels and shipped to Kodak's emulsion-making operations.

4. Gelatin is produced from animal hides and bone trimmings.

5. The silver nitrate crystals are combined with inorganic halide salts in the presence of gelatin, and other chemicals are added to produce a photographic emulsion.

6. This emulsion is then coated onto the film base in layers.

7. The film, base and emulsion, is slit to proper widths and packaged as rolls, reels, or cartridges.

8. Film is stored, under proper protective conditions, then shipped to dealers.

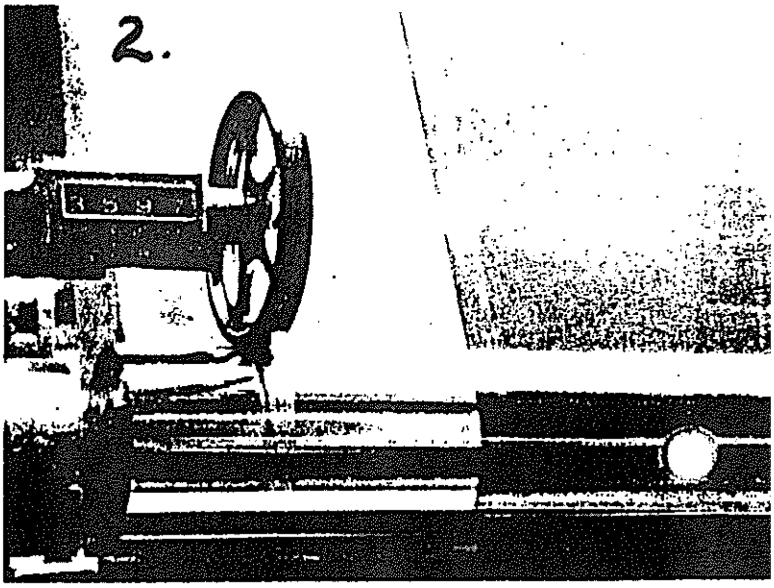
Exhibit 4

Filmmaking: Art and Science

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

- Cotton linters—from the South
- Wood pulp—from New England, the West Coast, and Canad
- Petrochemicals—from the United States
- Silver—from the United States, Canada, Mexico, and
- Bones and hide trimmings—from the United States an d
- Potassium bromide—from Arkansas and Michigan brine deposits

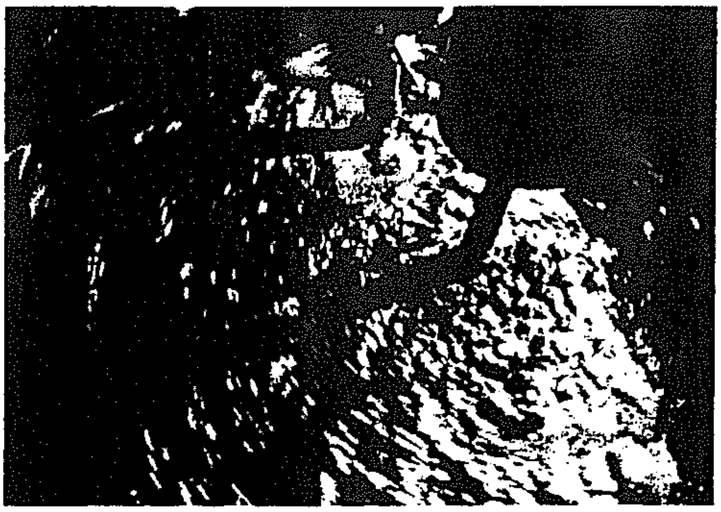
raw materials of photographic films include wood fibers, of refined silver, cotton linters, petrochemicals, hide trimmings ones, and the chemical, potassium bromide.



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

s of s r dissolved in acid ution produce nitrate crystals.

3.



4.

These crystals ar ed with potassium b e, gelatine and other chemical to form a photographic emulsion.

5.

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

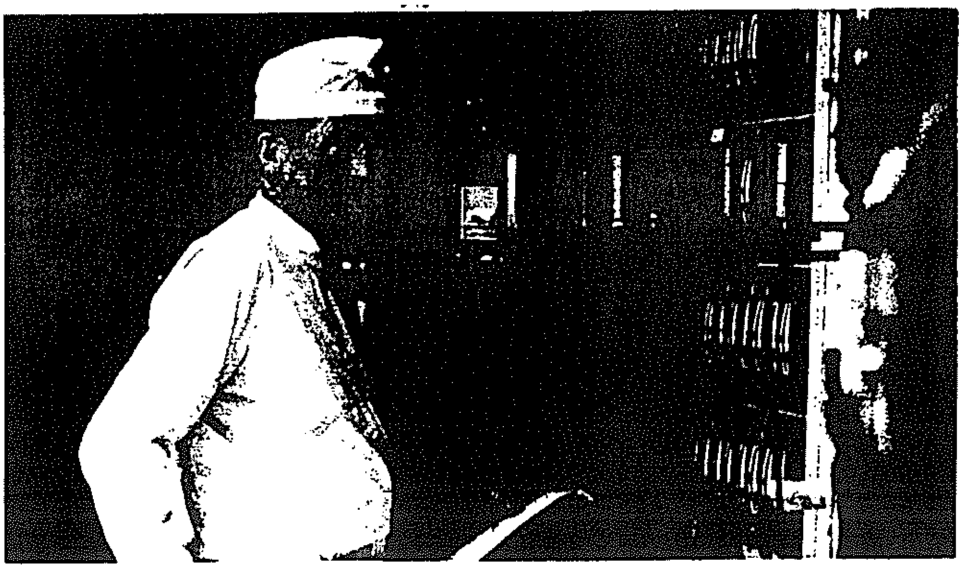


Exhibit 5

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

Potential Operating Effects in Gelatin Division
(dollars in millions)

	Most Conservative	Most Optimistic
Operating Savings		
Raw Materials	$12.0	15.0
Utilities	.5	3.0
Waste Water Treatment	1.0	2.0
Inventory Reductions (from raw stock and finished gelatin)	$ 1.5	5.0
Testing Reductions	(not estimated)	
Faster Response to Forecast Change	(not estimated)	
TOTAL OPERATING SAVINGS:	$15.0	$25.0
Operating Costs		
Chemicals--Additional Required	13.0	5.0
Net Annual Operating Savings	$ 2.0	$20.0
Capital Costs		
Experimental Work Order	$ 4.5	$ 3.0
Capital Expenditures for New Plant	$75.0	$17.0

Exhibit 6

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

Steps in Current and Proposed Gelatin-Making Process (Simplified)

Current Method:

Ossein Degreasing → Liming (2-6 months) → Wash → Extraction → Filtration → Evaporation → Deionization → Drying

Solagen:

Ossein Grinding → Reaction (48 hours) → Reverse Osmosis → Acid Quench → Denaturing → Pressure Filtration → Deionization → Evaporation → Drying

Exhibit 7

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

To: Mr. Alex Blanchard, CEO
From: Mr. Wayne LaFrance, Gelatin Plant Superintendent
Re: Solagen Presentation
Date: August 13, 1980

The word Solagen is being heard more and more frequently and the subject is growing in interest and importance. In my 33 years in the Gelatin Division, I know of no project that has created so much interest and has had so many pushing for action to see it develop and grow. Today we want to tell you of the status and plans for the Solagen program.

In 1977 interest in a Rapid Gelatin Making Process was revived from two interested groups. The Gelatin plants wanted to increase capacity and in order to achieve this needed to know more about the operating parameters of each step in our process. At this same time Fred Carson proposed a Research Program on Gelatin. A perfect match of a critical need and capable personnel to do the investigating work and solve the problems. There has been very close coordination of work and planning between the Gelatin Plant and Fred's group as they have tackled and solved the needs one after another in developing the process.

The Gelatin Division, user divisions, and all others participating are very enthusiastic about Solagen and want to get a pilot plant, the next step, operating as soon as possible. We do not have a 100% finished package all neatly tied up as yet for there is more refinement of the process that Fred has underway as we move into the pilot stage. Out of this Solagen work we see new technology which we will try to use in our present process as we build for Solagen.

Our Agenda Today:

Fred Carson--will compare the present process of making gelatin versus the new Solagen process. Solagen as you will see is far more than a rapid time saving process.

Antony Capicello--will cover the manufacturing impact (savings, costs, capital needs, utilities, ecology) and our time table as we advance to Pilot Plant, Prototype, and then Production.

William Bolten--will outline the implementation team, Gelatin Division action to date, retrofit of present process equipment, and summarize the key points of the program.

Exhibit 8

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

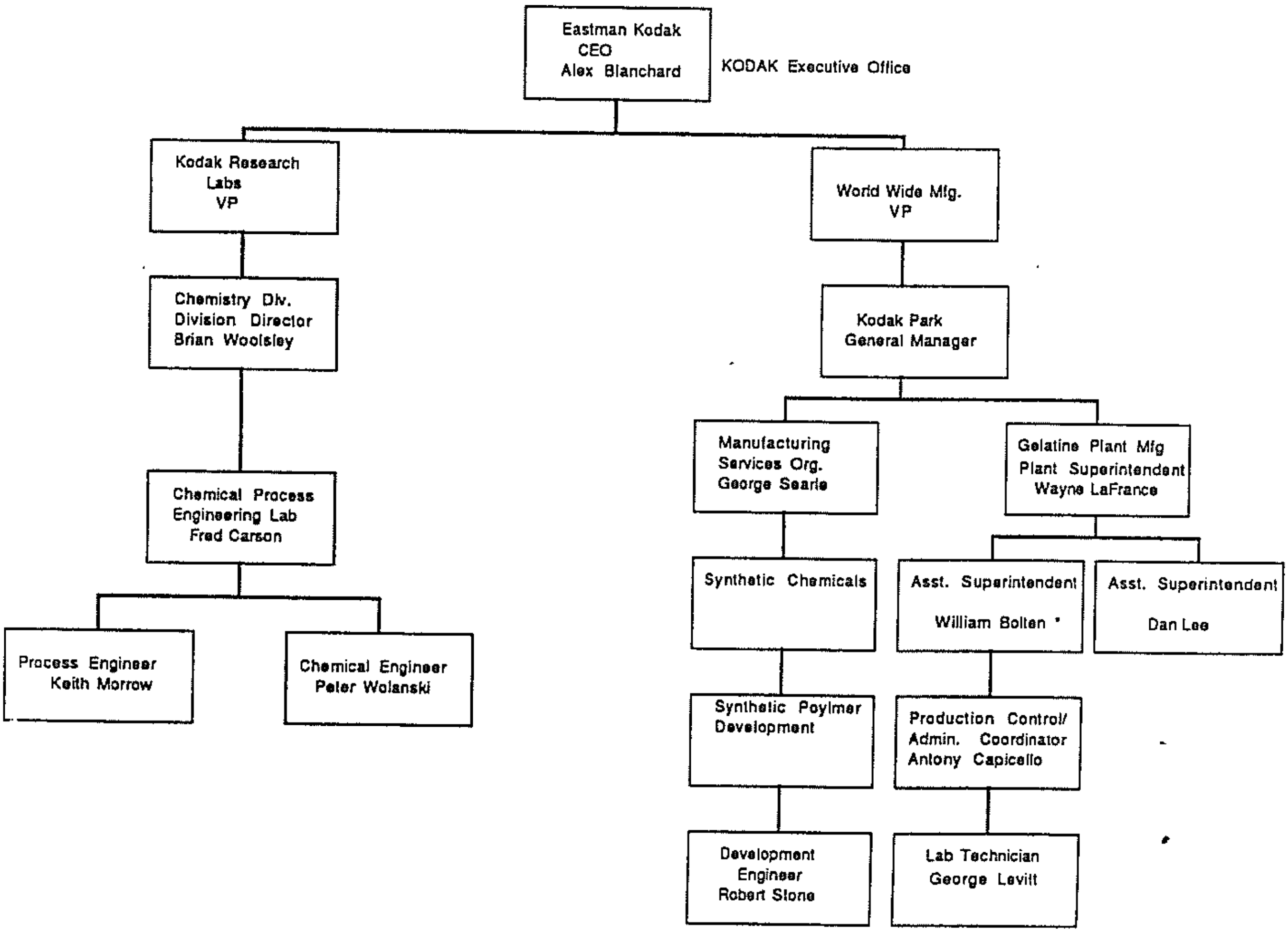
Proposed Project Schedule

Quarter	Research Activities for Solagen	Testing for Solagen
4th 1980	Gather data (R&D and Gelatin Production staffs).	
1st 1981	Specify pilot plant equipment.	
3rd	Install pilot plant equipment.	
1st 1982	Begin pilot operations.	Trials with full width photographic film. Specific product trials.
1st 1983	Design prototype.	Begin twelve-month product storage tests.
2nd	Gain Special Expenditures funding for installation and operation of new gelatin-making plant.	Special Expenditures Request Approval.
3rd	Begin construction of new plant.	
4th 1984	Complete installation of new plant.	Further testing of other products.
1st. 1985	Begin operation of new plant.	Convert one film and one paper product to new gelatin formulation.

Exhibit 9

SOLAGEN
Organizational Structure
Eastman Kodak Company

June 1980



Villiam Bolten became Gelatine Plant Superintendent in June 1981

Exhibit 10

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

Excerpts from 1981 Kodak Annual Report

MANAGEMENT COMMENTS

In spite of conditions which slowed economies in the United States and Europe, 1981 was a year of satisfying results for Kodak. Sales and earnings moved ahead, each reaching record levels. Dividends to shareowners increased for the 35th consecutive year...

Capital Expansion. A budget of $1,540 million for capital expenditures worldwide has been set for 1982, up 29 percent from the $1,190 million spent in 1981...

Research and Development. In the summer of 1981, a leading business journal published the results of its survey on the prior year's research and development spending of 744 U.S.-based companies. Kodak ranked in the top ten in dollars spent. Expressed as a percentage of sales, our R&D expenditures were nearly three times higher than the all-industry average.

In 1981, over $615 million was spent on Kodak research and development. A wave of new amateur photographic products were introduced within the past year as well as state-of-the-art photofinishing equipment. Several motion picture films were announced, including new Eastman color high-speed negative film. Other new and significantly improved products were brought forth in each of the market's divisions...

All of our new products reflect the continued strong return on the company's R&D investment...

The Outlook. For the past few years, many industrial countries throughout the world have been battling high inflation with policies of restraint. In the United States, economic policy makers have sought long-term solutions to the problems brought about by cost escalation and lagging productivity. At home and abroad, economic performance has been lackluster.

There are some signs now of a turnaround. The record-high interest rates which helped trigger the U.S. business recession have come down from their peaks. The rate of inflation is declining. These developments, together with planned cuts in personal income taxes, give rise to hope that a consumer-driven recovery will begin later this year.

If so, the latter part of 1982 and the years beyond should be a vibrant time for the photographic industry...

Exhibit 11

SOLAGEN: PROCESS IMPROVEMENTS IN THE MANUFACTURE OF GELATIN

1981 Kodak Annual Report
(dollar amounts and shares in millions except per share figures)

	1981	1980	1979
MANAGEMENT'S DISCUSSION AND ANALYSIS			
Sales	$ 10,337	$ 9,734	$ 8,028
Earnings from operations	2,060	1,896	1,649
Earnings before income taxes	2,183	1,963	1,707
Net earnings	1,239	1,154	1,001
EARNINGS AND DIVIDENDS			
Net earnings			
--percent of sales	12.0%	11.9%	12.5%
--percent return on average shareowners' equity	19.4%	20.2%	19.5%
--per common share	7.66	7.15	6.20
Cash dividends declared			
--on common shares	566	517	468
--per common share	3.50	3.20	2.90
Common shares outstanding at close of year	162.5	161.4	161.4
Shareowners at close of year	220,513	234,009	242,227
Earnings retained	673	637	533
BALANCE SHEET DATA			
Current assets	$ 5,063	$ 5,246	$ 4,522
Properties at cost	7,963	6,861	6,041
Accumulated depreciation	3,806	3,426	3,081
Total assets	9,446	8,754	7,554
Current liabilities	2,119	2,247	1,741
Long-term obligations	93	79	75
Total liabilities and deferred credits	2,676	2,726	2,163
Total net assets (shareowners' equity)	6,770	6,028	5,391
SUPPLEMENTAL INFORMATION			
Sales--Photographic Division	$ 8,258	$ 7,904	$ 6,458
--Chemicals Division	2,349	2,070	1,777
Research and development expenditures	615	520	459
Additions to properties	1,190	902	603
Depreciation	452	399	361
Taxes (excludes payroll, sales, and excise taxes)	1,026	881	770
Wages, salaries, and employee benefits	4,099	3,643	3,177
Employees at close of year--in the U.S.	91,900	84,400	80,800
--worldwide	136,400	129,500	126,300
SUBSIDIARY COMPANIES OUTSIDE THE U.S.			
Sales	$ 4,017	$ 4,125	$ 3,305
Earnings from operations	450	446	482
Net earnings (Eastman Kodak Company equity)	188	254	289