≪특별강연≫

The Interrelation and Interdependence of Chemistry and Chemical Engineering

*J. D. Park**

This relation isn't exactly true in a theoretical sense but in quite important and realistic in a practical and application sense.

The chemist normally is not interested in energy and material balances unless he's an explosive expert. The chemical engineer in the other hand in quite interested in these parameters. In fact, it is his "bread and butter" or in Korea, I suppose, one would say his "rice and kimchi".

In a utopian society devoted to the pursuit of knowledge for knowledges' sake, the isolation and segregation of these two cognate disciplines would probably not affect one another and each could go along it's merry way. However, in a material oriented society such as ours, and particularly in Korea at this critical embryonic stage, the union and cooperation of these two disciplines is not only necessary but essential for survival if Korea is to gain a place in the industrial world.

To illustrate, let us take the case of the studies that led to the commercialization of the "Freons".

In 1890, F. Swarts of the University of Ghent in Belgium, an organic chemist was deeply involved in the theoretical aspects of the effect of fluorine atoms in the organic molecule.

In 1928-29, Henne and Midgley of General Motors, both of whom were originally engineers were given the task of finding a new refrigerant to replace SO_2, NH_3 and CH_3Cl. Searching through the literature especially the Chemical Abstracts they came upon $CClF_3$ and CCl_2F_2 which they rightly concluded would be the ideal refrigerants.

At this stage, as a young and "green" engineer I was hired by them to repeat same of the earlier experiments of Swarts and also to help in the development of the process.

Swarts had prepared SbF_3 as the fluorinating agent form the reaction of Sb_2O_3 and HF. This was fortuitous since SbF_3 is quite stable in H_2O whereas $SbCl_3$ forms the oxychlorides quite readily. Remember also that only aqueous HF was available at the time in lead carboys or in paraffin bottles. We first made SbF_3 in wide-mouth salt bottles. Formation of SbF_3 took place in hot HF solution. Crystallization

$$Sb_2O_3+6HF\longrightarrow 2SbF_3+3H_2O$$

was allowed to take place under cooling conditions. Centrifugation of the wet crystals followed by sublimation gave anhydrous SbF_3. This material was then reacted with CCl_4 in the presence of Br_2 or I_2.

One can produce 50g or even 100g/day by this procedure but just think of the probem of making 10 lb of CCl_2F_2 by this process and in glass with HF as one of the reactants.

Here, the chemical engineer in me stepped into the picture. I changed my chemist's hat and put on my chemical engineer's overalls and hard hat. I ran corrosion tests to find the proper metal for use in construction. I found out how much heat, agitation, cooling, scrubbing, distillation, etc. was required so that a pilot plant could be designed and constructed.

*Professor of Chemistry, University of Colorado, Boulder, Colorado. On special assignment with IESC at KIST.
Presented under the joint sponsorship of the Korean Chemical Society and the Korean I nstitute of Chemical Engineers on July 28, 1970.

In the laboratory stages, the chemist in me wasn't concerned with the amount of heat input, coolant requirements etc.

In this simple transformation of a Dr. Jekyl—Mr. Hyde nature, one can see, how this interpendence and interrelation took place. I wasn't real good at either job—but with time, I gained experiences in both wich has stood me in good stead. At this stage of my dual career, I really didn't understand the duality of my work and what was more important—chemistry or chemical engineering? That I didn't know. As I look back now I believe it was my flexibility—my willingness to change, to learn new things—without the prejudices or preferences of either. At that time, in the depression years of 1929-33, I thought I stayed on because I had become accustomed to eating and jobs were scarce.

In fact, at one stage in this period I took up the study of law with the hopes of becoming a patent attorney but fortunately for me I gave up that idea the last year of law school.

This simple developmet went from the pilot plant into the semi-works stage and from thence into large production units capable of producing over 50M#/yr of "Freon" Now, let's take the case of the develop—ment of "Teflon" which was a serendipic discovery by Roy Plunkett at duPont 1938.

He had accidentally polymerized $CF_2{=}CF_2$ which was obtained from another "Freon", "F-114" which I had first developed at General Motors in 1930.

$$CF_2Cl-CF_2Cl \xrightarrow[\text{ROH}]{\text{Zn}} CF_2{=}CF_2 + ZnCl_2$$

(high pressure)

By this time, 1937 to be exact, I had returned from graduate school where I had turned in hard engg hat and concentrated in the chemistry of the car—bohydrates for my Ph.D. Ah! no more slide rule and nomographs for me. Just plain old slop-bucket chemistry. But this was not to be my destiny.

One of my first jobs at duPont was to find a new synthetic route to $CF_2{=}CF_2$. I devised the following set-up and was having lots of fun just giving the fluorochemicals the proverbial "hot-foot" I believe my chemical engineering back ground helped me to succeed where several others had failed. I made sure that I had the proper material balance and carried out my experiments in such a way as to minimize the probability of failure and if it failed, I woued know where the fault lay.

This study showed that the maximum yield and conversion of $CHClF_2$ to $CF_2{=}CF_2$ took place at 700-750°C when carreid out in an inert tube which in this case was carbon and which was later replaced by platinum.

Devlopment of this laboratory procedure again required the ingenious help of the practical minded chemical engineers. I also helped in a small way by getting some of the necessary data for the engineers such as the refrigerant load, meterial, energy balances, etc.

I believe you will find similar experiences in other fields. For example, the development of neoprene, nylon and lead tetraethyl.

All through my industrial apprenticeship I've been blessed by having undestanding and intelligent bosses—bosses who let me do what I wanted to do—and who had enough judgment and character to tell me to stop or continue when it came to make a decision. Midgley was a mechanical engineer turned chemist, and Henne was a chemical engineer turned organic chemist. Examples of the importance of the duality of training.

In their overall generosities, Henne and Midgley gave me more credit than I deserved. To them I owe a lot. Only in America can a second generation Oriental rise to a position of trust, prestige and honor as I have. In fact, I believe having slanted eyes, helped me to look at things differently.

Whether you're a chemist or an engineer, the most important quality (as I stated previously) is flexibility—it is this quality which accepts the expertise and contribution of others. It also makes judgment on the basis of merit and treats all with human dignity and charity.

We all must remember that the chemists or the chemical engineers do not have a monopoly of brains and imagination. They are true intellectual blood relations. The way to success for them and their ventures is to utilize the services of each other. Chemistry and Chemical engineering are not only complementary but supplementary to each other. We must always remember that marching side by side and in unity will the major technical problems be solved. In Korea this is important more than ever. Let us not forget the dignity of our fellow man. Let us all treat the less fortunate with human dignity. But for the grace of sod, you could be in his peace.

Since this union is so important, it is far more essential in Korea, where time is slowly running out, that the educational processes and facilities be changed may revolutionized.

The government and industry should support through grants and scholarships not only outstanding students but also professors so that Korea can compete for the services of key people without calling on them to perform by working on their patriotisim, family ties, etc. Some of you may rebut some or all of my statements—that is your prerogative but please do so with judgment and on a solid basis. I may be wrong, I could be wrong and I have been wrong but if I have hurt any of you and your pride and prejudices, please forgive me, for I err not from malice but from fondness and admiration for all of you and for my motherland.

Sure, you can point with pride to your industrial complexes you really have made great strides since the sixties. My hat goes off to you. You should stand with pride and point to your accomplishments. You have been able to buy "know-how"—both in chemistry and chemical engineering but remember the case of Soviet Russia. There one learns to run a plant but don't learn fundamentals of engg., process design, operation and scale up production. To a large extent, this is now true of Korea but I hope to God that it won't remain so.

With the same resolve, determination and drive you people have shown in opposing Communism and the progress you have made thus far, I'm sure Korea has the intelligence, pereverance and dexterity to transfer their efforts to the technologies of the modern industrial world.

You, the chemists and chemical engineers have the tremendous task of helping to bring these things to pass. It will require all of your joint talents and cooperation and I know, you all will be equal to the task. Sure, you will have to overcome bureaucracies of the various governmental agencies, universities and business but like all things someone must make the start. The start is half the battle won.

Before I finish, I would like to offer one suggestion. Many of you may have voiced it before but repetition should give it greater validity and strength. Korea must refrain from joining the international patent convention. She is in no position at the present time to compete with other developed nations for patent converages. If she joins at this stage, she'll be opening the "flood-gates" to all nations especially Japan, U. S. A., England and Germany to seek coverages in Korea—this would "hamstring" Korea's industrial progress for decades to come and virtvally force her to pick up the crumbs which fell off the banquet tables instead of sitting at the table feasting on the fruits of her labors.

I'd like to illustrated by another example not only the interdependence of Chemistry and Chemical engineering but the need to use youbrains with intelligence and not blend rate. Exercise of judgment is very. necessary. Take the ease of a tank car (10, 000 gal) of leaking Chlorine at a wharf siding. What would you do with it under the circumstance.? Dump is overboard! Pump it into another tank car. Weld it!

In conclusion may I add, I'm very happy to have this opportunity to talk to you. To you young people and us old poople with flexible spirits and minds—to all us—Chemists and chemical engineers alike—I throw you a challenge. The world of industrialization is upon Korea—Are you up to it? Can proud Korea—and proud and capable Koreans afford to fail where Japan has succeeded. You and you along have the answer.