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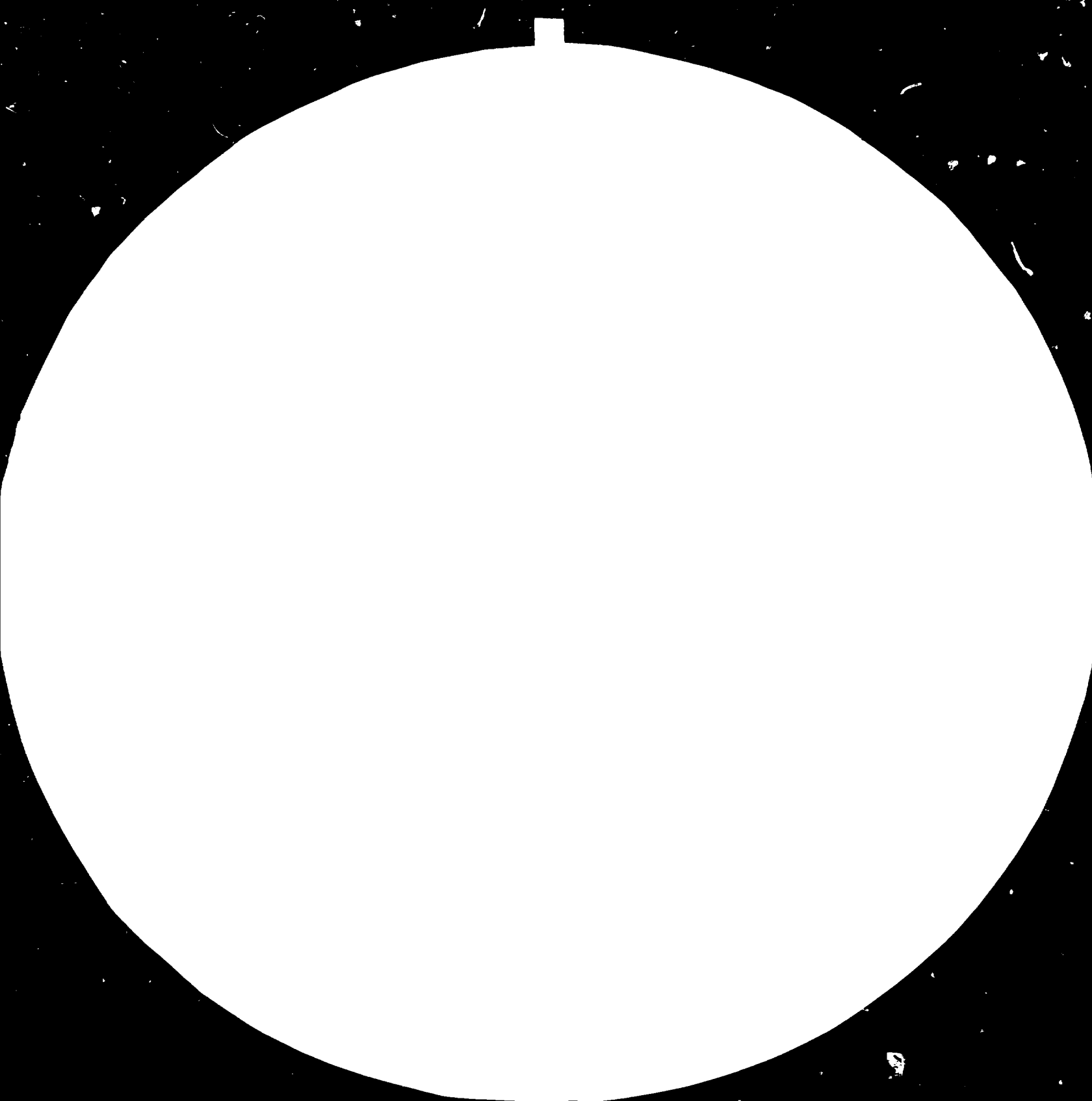

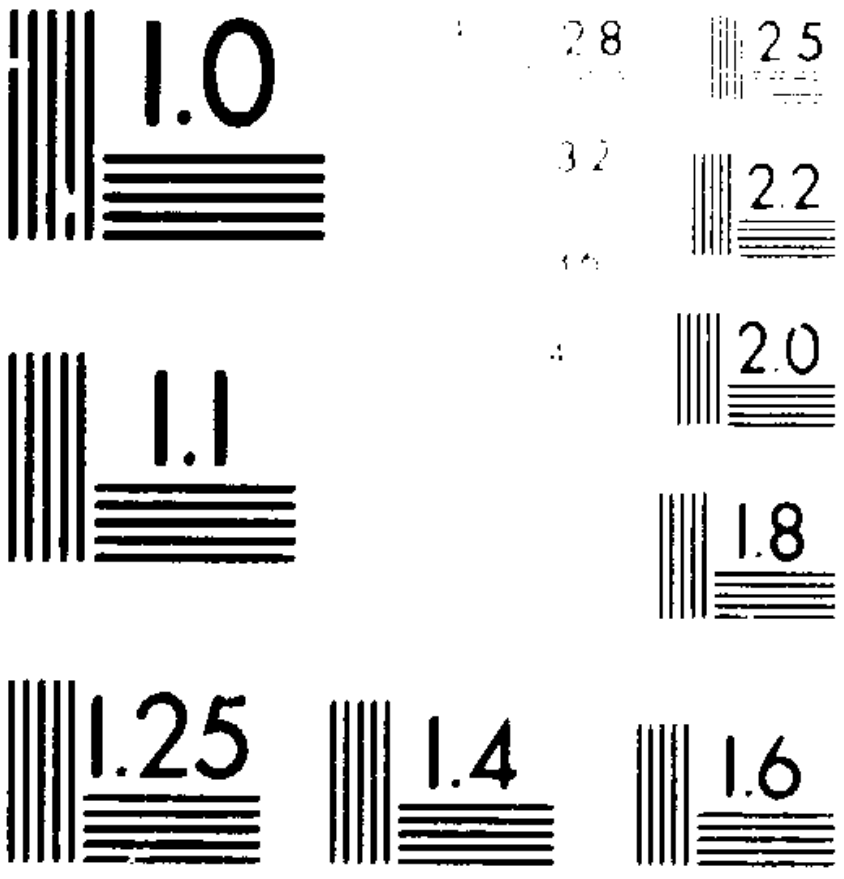

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August 1984
English

DPR of Korea.

PVC COMPOUNDING AND PROCESSING

Si/DRK/83/802/11-02/32:1.H

Final Report

Prepared for the Government of DPRK
by the United Nations Industrial Development
Organization, executing agency for the United Nations
Development Programme

Based on the work of Levon Vardanyan, expert
UNIDO in the field of PVC compounding and processing
/mission 23 July-13 August/

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CONTENT

I. SUMMARY

During Mr.L.Vardanyan mission to the Institute of High Molecular Chemistry, Hamhung, DPRK (period 23 July-13 August 1984) the detailed acquaintance with scientific and technological problems in the field of PVC-compounding and processing was carried out.

The close daily collaboration with the institute's scientists gave the opportunity to find out the main problems in this field, which are:

- The very low quality of the industrial PVC-polymer.
- The absence of the scientific methods for creation PVC-compounds and their processing in final products.

The ways for overcoming these problems were out-lined.

II. INTRODUCTION

I arrived at Pyongyang airport, Democratic People's Republic of Korea in the morning on July 23, 1984.
I was welcomed by Mr.Kim Chen Jin, Head of laboratory of the Institute of High Molecular Chemistry (IHMC), in Hamhung, my counterpart, and by Mr. Hea Don Ir, senior Scientific worker of the same institute.

On the same day I visited the UNDP Office in Pyongyang, where I met Mr. Ram Narain, Assistant of Resident Representative.

On the next day I was introduced to Mr. Richard Millar, Resident Representative, a.i. for my briefing.

In the morning on July 25 I arrived in Hamhung (my duty station) and was introduced to the staff of IHMC immediately.

I set about my duties with a discussion of the work programme. /see Annex 1/

During my mission at duty station I had opportunity to become acquainted with the details of the two laboratories engaged in "PVC-compounding and processing" project namely, "PVC-polymerization" and "PVC-processing".

I visited the two local plants where processing of PVC into final flexible and rigid products is carried out. Also I visited the famous "Vinalon"-complex where I was acquainted with PVC-production. (Annex 2)

During my mission at the IHMC I delivered 6 lectures on the following subjects:

1. "Today and tomorrow of PVC in the world production"
2. The selectivity of stabilizers of PVC as one of the main problems in PVC-compounding and processing
3. Physico-mechanical properties of PVC-and PVC-compounds and the methods of their evaluation
4. The application of the PVC-materials
5. The fillers for PVC-compounds
6. Polyester plasticizers-a new class of plasticizers for PVC.

The programme on the "PVC-compoun ing and processing" project was completely finished on 13th of August.

III. BACKGROUND INFORMATION

The Institute of High Molecular Chemistry (IHMC) was established in 1960 within the Academy of Sciences located in Hamhung. The total institute staff is 250 of which 110 are scientists, post graduates and graduates.

The institute includes 8 laboratories and organized along the following lines:

Laboratory 1- PVC synthesis by suspension and emulsion polymerization

Laboratory 2- Synthesis of polymers with insulation properties and polyamides

Laboratory 3- PVC and polyethylene processing laboratory

Laboratory 4- Laboratory of Vinalon quality improving

Laboratory 5- Synthesis of PVC fibres

Laboratory 6- Rubber synthesis on the base of chloroprene and calcium carbide

Laboratory 7- Rubber processing laboratory

Laboratory 8- Synthesis of suspended dye laboratory

There is a rather large library at the Hamhung Section of Academy of Science. The collection of books and journals is printed mainly in the Korean, Japanese, Russian languages and just a few of them are modern.

The institute has close working relationships with industry and the majority of research and development projects carried out are based on requests received from industry.

For better understanding and solving the "PVC-compounding and processing" problem I visited with my counterpart the three local plants being engaged in production of PVC-materials.

There has been a significant rate of growth in the production of PVC polymer during the last decade in the world.

The main reasons for this exceptional growth are:

1. The relatively low price of the polymer;
2. Its versatility, since it can be made into a variety of products from rigid sections to soft elastomers in complete range of colours and transparencies;
3. Its good physical, chemical and weathering properties;
4. The development of better polymers;
5. The development of improved stabiliser and lubricant combinations;
6. The development of a wide range of high quality processing equipment;

Vinyl chloride can be polymerized by several different routes. These include suspension, emulsion, mass and solution polymerization technique. Each one of these techniques produces PVC as fine powders which are similar chemically but can differ considerably in particle structure.
It is the latter property that has the greatest effect on the polymer's performance during processing. Other important properties which also affect the polymer's processing characteristics, are molecular weight, particle size distribution and irregularities within the polymer chain.

At the "Vinalon"-complex, the vinyl chloride obtained from acetylene is polymerized by suspension (approximately 95%) and by emulsion routes. Total capacity of the unit is 50000t. per year.

Suspension PVC is manufactured by stirring vinyl chloride and water in the presence of dispersion agent and an initiator (catalyst) which is soluble in the VC monomer.
The dispersion agent promotes the formation of small stable droplets of monomer.

Polymerization occurs within each droplet of vinyl chloride with the water acting mainly as a heat sink to remove the heat of polymerization, thus allowing careful control of the temperature of reaction to be maintained.

The choice of dispersion agent and degree of agitation during the polymerization are very important in deciding the structure, shape and particle size distribution of the final polymer. By controlling these variables highly or smooth spherical particles of various densities can be produced. The particle type and structure have a considerable effect on the processing characteristics and other important properties such as therate of plasticizer absorption.

Compared with emulsion polymers, the main advantages of suspension polymers are that they are cheaper and have better characteristics. This has led them to be used increasingly for dry blend extrusion of rigid PVC products.

The process of suspension polymerization of vinyl chloride at "Vinalon"-complex is carried out at 60°C periodically, using azobisisobutylonitrile (AVTN) as initiator, and polyvinylalcohol as dispersion agent.

Here I noticed that final polymer powder was not white, and had greyish-pink colour, and its particle size was rather large. Following discussions it was apparent that both these factors were due to the quality of the final PVC-Polymer not being high.

I then visited a local plant where different types of PVC-films, wall-papers, linoleum were manufactured by calendering method. Having become acquainted with the composition of these PVC-materials, I paid attention to the fact that used stabilizers everywhere were the same- the Pb-and Ba-stearates.
On my opinion, they were not chosen in the right way.

The selection of the correct stabilizer for a PVC-compound is probably the difficult task facing the compounder.
The stabilizer selected can exert a great influence on the final appearance and properties of the compound and, therefore, has a marked effect on the sales potential of the finished product. The problem is made even greater by the wide selection of stabilizers which are available and which, to some extent, overlap in their properties and have an influence on the stability of the PVC compound.

In addition, many of the products available behave synergistically with each other to provide better overall stabilization. Admittedly, some of these groups are far more important than others but it is fair to say that all of them play an important part in the stabilization of PVC.

Futher I was at a small plant of local industry of PVC-processing into rigid films by calendring. The manufacturing of the PVC-rigid films is a very difficult technological problem although the extruding has been approached for this purpose.

It is difficult correctly to select all ingredients of the PVC-compound. The nature and amount of stabilizer and lubricant play a very essential role.

While at this plant I paid attention to the absence of any antioxydants and lubricants in the processing PVC-compounds.

The role of the lubricant particularly in rigid PVC technology is almost as important as that of the stabilizer. Many different types of compounds are available as lubricants and they are usually sub-divided into internal and external types.

The external lubricant functions as a lubricating layer between the polymer and metal surfaces of the processing equipment.

It has low compatibility with the PVC particularly at processing temperatures so that it can exude towards the surface.

As a result of this, it will also form a lubricating layer around the individual particles of the PVC and thus retard the rate of gelation.

Internal lubricants are much more compatible with PVC. Its use will reduce the melt viscosity of the polymer, improve the flow characteristics and reduce the frictional heat during processing.

Therefore, based on my impressions I concluded that the industrial PVC-product did not meet processing requirements and it is necessary to expand the knowledge and techniques as regards stabilization, lubrication and general processing of PVC into final products.

IV. RESEARCH AND DEVELOPMENT PROGRAMME

According to my mission I concentrated my expert's activity on the problems of two laboratories of IHMC namely PVC-polymerization and PVC-processing.

Taking into consideration the rather rich sources of raw calcium carbonate, high demand for PVC and PVC-materials, the government policy directed towards independence on imports and the present research and technological problems, I selected two main projects to be carried out in the IHMC.

a) Project 1.

PVC-polymerization

Personnel: 23 empl., 1 Doctor of Sc., 4 Ph.D., 6 Senior Sc. W., 4 Junior Sc.W. and others.

Head: Mr. Kim Chen Jin.

The DPRK has no petroleum-oil or natural gas that can be used for production of olefins, in particular, vinyl chloride. This situation is to be solved by using the acetylene from calcium carbide as an alternative starting material.

The vinyl chloride is polymerized by suspension route (approximately 95%) and by emulsion route at the "Vinalon"-compl x. Total capacity of the unit is 50 th.t per year.

The purpose of this project is improving the different technological stages of vinylchloride polymerization to obtain the PVC-polymer with high quality properties.

The staff of PVC-polymerization laboratory investigates two types of vinyl chloride polymerization, studying the suspension and emulsion methods.

Reactions are carried out periodically in 5 lt apparatus by the different types of initiators under various conditions. A few problems of improving of microstructure of the obtained PVC-polymer are solved also.

The industrial PVC-polymer represents a rather big size powder with greyish-pink colour, that has very low thermostability. All these factors are spoken of as a very irregular structure of PVC-makromolecules.

This is one of the main causes of bad properties of PVC-polymer.

Recommendations: for improving the microstructure of the PVC-polymer, and consequently, the quality, I suggest:

- to carry out the research work on superpurifying vinylchloride from any ad-mixtures, non-reacted acetylene in particular;
- to apply more effective peroxide initiator instead of today "avin"-initiator;
- to change or modify the dispersion agent based on polyvinylalcohol to a more effective one.(Annex 3)

b) Project 2.

PVC-processing

Personnel: 20 empl., 2 Ph.D., 4 Senior Sc.W., 6 Jounior Sc.W. and others.

Head of laboratory: Mr. Han Bom Do.

The staff of the laboratory investigate the different physico-chemical and physico-mechanical properties of obtained PVC-compounds. A number of processing problems are also solved here.

However, the limited quantity of laboratory equipment and apparatus is restraining the development for study of PVC-compounding and processing. Moreover, much of the units are very old.(over 15 years)

I suggest staff of the laboratory concentrate the activities on developing scientific methods for creation of PVC-compounds. I mean the wide variety of additives namely-plasticizers, extenders, stabilizers, lubricants, fillers, which can be used with PVC to yield different end results and considerable range of products.

Recommendations: for improving the scientific level in the field of PVC-compounding and processing, I suggest:

- to investigate new types of lubricants;
- to research new stabilizers for flexible and rigid PVC-materials;
- to establish scientific base for methods of PVC-processing. (Annex 4)

V. RECOMMENDATIONS

I think that it is very expedient to establish the new laboratory in the IHMC. namely, laboratory of fillers for polymers.

Fillers are normally incorporated into polymers to act as extenders which reduce the overall cost. They are also added to opacify the compound or to bring about other describle properties for specific applications. The main disadvantage to the use of fillers is that they may detract from the tensile strength of finished products. They can also exert a marked effect on the processing characteristics of the PVC-compound depending on the type of filler used. Certain fillers can also be included to bring about an improvemert in the impact strength of the PVC. Several different types of compounds are in commercial use today.

One of the most wide-spread is calcium carbonate for PVC-compounds.

In this way, on the one hand, in my opinion, activity of this laboratory could be based on the rich sources of raw calcium carbonate. On the other hand, one would expect to have a good cooperation with the institute of inorganic chemistry in Hamhung to deal with this problem.

VI ACKNOWLEDGEMENT

I should like to thank the Government of the Democratic People's Republic of Korea and the Academy of Sciences for the efforts and attention which I felt during my mission.

I highly appreciate my counterpart Mr. Kim Chen Jin, the head of laboratory and Mr. Han Bom Do, Deputy Director, a.i. of Institute of High Molecular Chemistry for their help and creating a friendly atmosphere for free exchange of knowledge and opinions during all my work in IHMC.

I thank the staff of IHMC for their help and participation in my work.

I thank all Korean People I met for their kindness and hospitality.

I thank the members of the UNIDO Chemical Industries Branch and the members of the UNDP Office in Pyongyang for their help.

Expert UNIDO

L. Vardanyan.

Annex 1

Institute of High Molecular Chemistry. AS.DPRK.

Work programme in "PVC-compounding and processing" problem during the UNIDO expert L. Vardanyan mission
/ period 23 July-13 August 1984 /
Si/DRK/83/802/11-02/32.1.H

Duty station-Hamhung

The work programme has been prepared in accordance with the job description, in consultation with the authorities and included the following activities:

1. Acquaintance with the structure of IHMC and particularly with the laboratories involved in "PVC-compounding and processing" problem
2. Working out of work programme on this problem in detail with the national counterpart specialist.
3. Detailed acquaintance with the "PVC-polymerization" laboratory
4. Detailed acquaintance with "PVC-and PEt-processing" laboratory
5. Visiting "the semiplant of PVC-production at "Vinalon" -complex
6. Visiting the two local "PVC-processing"plants
7. Giving lecture-"Today and tomorrow of PVC in the world production"
8. Discussion of observations with the counterpart.

Period 1-7 of August

1. Giving lecture- The selectivity of stabilizers of PVC as one of the main problems in "PVC-compounding and processing".
2. Discussion with laboratory staff on the research work and recommendations.
3. Giving lecture- Physico-mechanical properties of PVC-and PVC-compounds and the methods of their evaluation.
4. Discussion of observations with counterpart and recommendations.
5. Giving lecture- The PVC-material application
6. Giving lecture- The fillers for PVC-compounds
7. Giving lecture- Polyester plasticizers-a new class of plasticizers for PVC.
8. Discussion of the expert's suggestions about project.

On behalf of HHC AS.DPRK

Deputy Director a.i.

Han Bom Do

Sign

On behalf of experts of UNIDO Representative

Levon Vardanyan

Sign

27 July, 1984
Hamhung.

Annex 2.

Professionals participating in meetings and discussions

1. Sin Ben John- The first deputy Director of Academy of Sciences Hamhung Section
2. Kim Chang Ha- Instructor of the Hamhung Section of Academy of Sciences
3. Han Bom Do- Deputy Director a.i. of IHMC, head of laboratory
4. Kim Chen Jin- Head of laboratory of IHMC
5. Le Ben Un- Head of laboratory of IHMC
6. Kim Ben Du- Head of laboratory of IHMC
7. Jo Son Ho- Head of laboratory of IHMC
8. Lee Te Meu- Senior Scientific worker of IHMC (S.S.W.)
9. En Cyn Zon- S.S.W.
10. Pak June He- S.S.W.
11. Ok Tee Hoon- S.S.W.
12. Pak Chen He- S.S.W.
13. Sin Mu Gil- S.S.W.
14. Yun Chan Gyn- S.S.W.
15. Chen Gem Uk-S.S.W.
16. Chem Ze Gen- Junior scientific worker (JSW)
17. Kim Gan Chune- JSW
18. Pak Un Fein- JSW
19. An Don Hoon- JSW
20. Kim Ben Man- JSW
21. Lee En Fil- Deputy Chief engineer of "vinalon"complex
22. Lee Hon Tak- Chief engineer of PVC -shop in "Vinalon"-complex
23. Tscy Gan Su- Chief engineer of plastics-processing plant
24 Kim Son Zin- Instructor of plastics-processing plant
25. Kim Geen Bok- Director of plant for children goods
26. Luy Zu Un- Chief engineer of plant for children goods

Annex 3

Equipment required in Project 1

Item	Description	Quantity	Cost. US. $
1	Infrared spectro-photometer	1	20,000
2	Gel-chromatograph	1	20,000
3	Light scattering photo-meter	1	20,000
4	Differential thermoanaly-ser	1	10,000

foot-note: in the DPRK current frequency is 60 Hz.

Annex 4

Equipment required in Project 2

Item	Description	Quantity	Cost.US $
1	"Brabender" plasti-corder with extrusiograph	1	40,000
2	Electro-mechanical Universal Testing machine, "Shimadzu" autograph with template for "contour-cut"	1	25,000
3	"Scamia" Combined laboratory machine (7 uses)	1	25,000
4	Ultra-thermostat as CEAST UW/Pl.2	1	1000
5	"Oxygen-index" Apparatus CEAST	1	10,000
6	Reoscop 1,000, CEAST with viscosimeter "Kastor-severs	1	25,000
7	Apparatus for measuring dielectric properties	1	15,000

foot-note: in the DPRK current frequency is 60 Hz

We were acquainted with the final report "PVC-production and processing" prepared by L.Vardanyan, expert UNIDO.

We consider that his work at the Institute of High Molecular Chemistry was successful, and his recommendations are right and useful.

Deputy Director a.i.

Han Bom Do.