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PROCESSING AND APPLICATION OF ADVANCED MATERIALS

Case study: Nigeria*

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Abstract

An analysis of the materials substitution efforts and materials consumption pattern shows that the total volume of raw materials obtained from developing countries will not reduce significantly in the near future. However, the wide range of materials available to the western world, which is the largest consumer of materials, takes price dictation out of the hands of the developing world. Apart from economic considerations, the aggressive search for substitute materials by western world is fuelled by political and security considerations. The developing world is thus faced with the risk of losing some of its little political and economic base. Increased consumption of materials for the production of services and goods by developing countries is seen as the answer to the situation. Consumption of materials by the developing world is limited by technological know-how, infrastructural facilities, inadequate data base and poor information dissemination. This has profound negative effect on materials development activities. Nigeria has responded to the situation by establishing a Council to coordinate all raw materials development activities in the country. The programmes of the council which include stock taking of raw materials, facilities, and activities in the country is recommended to other developing countries. It is also suggested that relatively simple technologies should be exploited. In the case of Nigeria modification of concrete cement and utilisation of smaller diameter wood and coarse chips from waste wood or old wood for production of plywood, fiberboard and particle board provide fertile areas for development. Developing countries are also called upon to support the activities of the Action Committee on Raw Materials.

Introduction

The pages of news papers at home and abroad often carry stories of starvation and deaths through diseases in developing countries. One is tempted to conclude that the developing world should devote more time to agricultural matters and primary health care rather than dissipate energy on advanced materials development. However, considering the fact that the economy of these countries are sustained mainly by exportation of raw materials, they can not ignore the threat, if there is any, posed by the replacement of their raw materials by new materials. Moreover, in the past the developing world stood by and watched while new technologies were developed and struggled to use the technologies after they are obsolete. Next to the computer revolution, the materials revolution, characterised by the replacement of traditional materials, such as steel, copper, aluminum, glass, cotton, wool, and paper, with organic synthetic materials, has

had the greatest impact on modern man than any other development. In view of these it is timely that these forum is discussing the issue of new materials.

What are advanced or new materials?

Advanced materials are often simply improved conventional materials, as for example in the development of the families of superalloys used in modern gas turbine (1). A material may also be classified as new when it is used in a technology originally based on another material. The development of various plastics to replace wood, steel and other metals is a good example.

The development of new materials provide wide choice for consumers. For example, the beverage industries has the choice of glass, tin-coated steel, aluminum, plastics or paper for packaging (2). The indispensability of many metals in several applications is now questioned as aggressive efforts are made to replace them with polymers, pre-stressed concrete, optical fibres, composites and ceramics.

The European Commission selected 53 projects within the multi-annual research and development programme on substitution and materials technology in 1982-1985 (3). The issue was addressed under five different programmes:

- a. Substitution in electrical contact materials;
- b. Substitution in magnetic materials;
- c. Substitution in surface treatment and coating materials;
- d. Substitution in hard materials and tool materials; and
- e. Substitution in steels and in soldering and brazing materials.

These research efforts can be summarised as follows:

Table 1 Summary of Research Efforts of The European Commission's (1982-85) multi-annual research and development programme on substitution and materials technology

<u>Materials being replaced</u>	<u>Substitute Materials</u>
Silver (Programme 1)	Copper
Silver "	Nickel
Chromium "	Vanadium, cobalt or iron
Cobalt,) (Programme 2)	Iron, Aluminum, Carbon, Manganese
Samarium)	Copper, zirconium, Praseodymium

		Neodymium, Boron
Chromium	(Programme 3)	Nickel, alumina, silicon carbide titanium, zirconia
Tungsten Cobalt	(Programme 4)	Nickel, molybdenum, manganese, iron
Tin	"	Aluminum, Steel
Steel	"	Iron composites fibre-reinforced cements
Chromium	(Programme 5)	Aluminum and silicon
Tin	"	Zinc
Silver	"	Copper and phosphorus

For the purpose of these research efforts silver, chromium, cobalt, samarium, tungsten, steel, and tin are new materials. Other materials such as gallium, indium, arsenic, niobium, zirconium, yttrium, ytterbium, and neodymium serve as new materials in the microelectronics, photonics, advanced magnetic systems and super conductors industries. It should be noted that many of these materials, like steel, copper and cobalt feature as both new and conventional materials, depending on application.

How does the development of New Materials affect demand of Materials from the developing countries?

In order to address this question it is useful to take a look at the world reserves of minerals. Table 2 shows that the developing world accounts for a large percentage of world's reserves of bauxite, copper, tin, cobalt, columbium, tantalum, and phosphate, while vanadium, chromite, platinum and potash are found in lesser quantities in the area.

While the emergence of fibre optics may result in reduced demand for copper for electrical and electronics purposes, the replacement of silver by copper will result in increased demand (by volume). The replacement of chromite by cobalt will also be a volumetric increase in demand of materials from the developing world.

Many of the new materials find their bases in petrochemical. A striking example is the substitution of various plastic composites for steel. It is noteworthy that while the world's reserve of iron ore is dominated by the central economies and the western industrial countries, the larger fraction of the world's reserve of petroleum is found in developing countries.

Many of the materials being substituted have other applications. Chromium for example is one of nature's most versatile elements with a wide range of different uses. Chromium plays an important role in the production of armor plates, gun barrels, projectiles, heat resistant machine parts, crankshafts, axles, and gears. In the chemical industry, chromium helps to produce pigments and to process leather; and in steel and special steel furnaces it is used for refractory purposes. It is estimated that about 70% of chromium in the western world goes to steel production, 12% to chemical and the refractory industry the remainder (4).

Cobalt is an important alloying mineral for steel and also for production of superalloys because of its heat resistance, its high strength and its magnetic properties. The metal has also been used since about 2000 B.C. as a pigment to colour glass. It is estimated that about 30% of the world consumption of cobalt is accounted for by steel alloys, about the same percentage by magnets and related uses in the electric industry, about 25% by the chemical industries, about 6% by carbide production (as cement), about 4% by high speed steel and the remainder by other miscellaneous applications (4).

Tungsten finds various applications because of its high smelting point and hardness. Steel industry accounts for about 20% of tungsten consumption in the Western world. Tungsten carbides, used in machine tools, mining tools, wear pads, drilling bits etc. account for about 55% while about 27% is used in lamps and lighting, other electrical applications, and dyeing in chemical industry (4).

The foregoing discussion suggests that the volumetric requirement of raw materials from the developing world will not necessarily decrease in the near future. However, this observation does not call for celebration. Table 3 shows the distribution of the world's consumption of metals. Developing world and Africa in particular consume only a small percentage. Thus, the consumption pattern of the rest of the world especially the western industrialised nations dictates to a large extent the prices of these metals and hence the foreign exchange earnings of the developing countries. With the development of several alternatives (new materials), the western world can choose with ease their source of materials.

The interest in new materials is not fueled only by economic considerations. There is the issue of politics and national security. It has been argued that the highest risk to mineral supply to the western world is concentrated in South Africa and the Persian Gulf and that the minerals with the highest uncertainties are, in order of importance, oil, steel alloys, natural gas, cobalt, platinum, and phosphate. The frantic search for alternative source of energy is mainly catalysed by the apparent vulnerability of the western world to OPEC oil embargoes and rapid price rises in times of crisis (4).

Table 2 World reserves of minerals: regional distribution, 1985-1986

Commodity	World (thousands of tons)	Europe	North America	Latin America	Africa	Asia	Australia/ Oceania	Central- economy countries	Western indust- rial countries	Develop- ing countr- ies.
Bauxite	2103400	5	0	28	33	9	21	4	26	70
Copper	337000	1	22	33	18	5	4	17	26	57
Lead	86500	12	35	6	6	3	17	21	67	12
Zinc	147600	15	29	12	8	11	11	14	64	22
Tin	3240	4	2	8	5	65	6	10	13	77
Iron	65502000	4	12	18	5	7	14	40	34	26
Chromite	1057700	2	..	1	81	3	0	13	80	7
Manganese	925500	3	51	2	7	37	47	16
Cobalt	3564	1	1	0	49	10	7	32	4	64
Molybdenum	5307	..	60	26	..	1	..	13	60	27
Nickel	44400	7	17	5	7	13	27	24	34	42
Columbium	4125	..	3	78	2	0	..	17	3	81
Tantalum	23	..	8	7	16	35	20	13	27	60
Ilmenite (TiO ₂)	177800	19	22	1	21	19	13	5	75	20
Rutile (TiO ₂)	19750	..	1	1	21	26	44	7	55	38
Vanadium	7165	0	3	0	56	0	0	41	59	0
Tungsten	2630	5	24	3	1	5	3	59	32	9
Zirconium	36100	1	20	2	19	9	32	17	72	11
Gold	40	0	10	6	62	3	4	15	72	13
Platinum meals	31	..	1	..	80	19	81	..
Silver	244	3	26	29	4	3	11	24	40	36
Phosphate (P ₂ O ₅)	8543300	0	20	6	59	6	0	9	22	69
Potash (K ₂ O)	8715000	5	52	1	..	2	..	40	57	3
Fluorspar	89300	17	8	16	36	7	0	16	54	30

Source: ATAS Bulletin Issue 5 May 1988

Table 3 World metal consumption (refined) - regional distribution, 1985

Commodity	World (thousands of tons)	Europe	North America	Latin America	Africa	Asia	Australia/ Oceania	Central- economy countries	Western indus- trial countries	Develop- ing countr- ies.
Aluminium	16253	25	29	5	1	17	2	21	67	12
Copper	9613	29	22	5	1	16	1	24	65	11
Lead	5421	30	22	5	2	13	1	27	61	12
Zinc	6492	26	17	6	2	19	2	28	57	15
Tin	213	26	19	5	1	21	1	27	61	12
Raw steel (1983)	656331	18	16	3	2	19	1	41	45	14
Nickel	787	28	20	2	1	21	1	27	67	6

Source: ATAS Bulletin Issue 5 May 1988

Getting away from being just raw materials suppliers ; Nigeria as Case Study

The idea of value addition has been discussed in many gatherings. However, the developing countries have not addressed this problem squarely. A major gap in the developing countries is the absence of technology for processing these raw materials. More basic is the absence of reliable data and poor information dissemination.

Nigeria has recognised these problems and responded by setting up an organisation, the Raw Materials Research and Development Council in 1988 with the mandate to encourage optimal utilisation of the countries raw materials and to assist the existing industries to obtain their raw materials.

The Council took stock of the raw materials of the nation and the various industrial and R & D activities in the country. The available technologies for raw materials processing and the local capability for equipment fabrication were also documented. In recognition of the vital role of data, the Council established a data bank from which information are drawn to serve the industrialists, researchers and other interested parties.

Many entrepreneurs will not venture into areas considered new unless proved to be profitable. The Raw Materials Research and Development Council has embarked on the establishment of small scale materials processing industries (in collaboration with State Governments) to stimulate entrepreneurs to venture into raw material processing industry.

There are a number of indigenous raw materials processing technologies that may be upgraded to industrial scale. These are being studied with the ultimate aim of drawing out a comprehensive programme for upgrading.

As earlier stated Polymer play a critical role in the replacement of materials. However, while no chemical reactions is involved in the formation of metal alloys, synthetic polymers require forming entirely new chemical entities. Mixing polymers to form alloys is thus relatively difficult. This is no excuse for the country to be left behind in new materials development. Though the Government may not be able to set up a Materials Research Centre immediately, the relevant departments in the universities should be upgraded to address research activities in this area. There is also the need for researchers in the universities and other R&D institutes to share facilities.

Attention should be focused on relatively simple raw materials processing technologies that are of importance to the nation. For example, concrete production technology is relatively simple and, because of the rich choice of materials (see Table 2) and many possibilities during manufacture, a wide range of products with various properties are obtainable.

Wood and wood-based materials also provide another area for simple research. The utilisation of smaller-diameter wood and coarse chips from waste wood or old wood for production of plywood, fiberboard and particle board provide a fertile area for development.

The Council is currently the secretariat of The Action Committee on Raw Materials under the Group 77. The immediate objective of the Committee is finding solutions to raw materials and technology problems through national, regional and international co-operation in areas of trade, training, research and development, management and data processing, marketing and distribution of raw materials. All developing countries should be committed to the programmes of the Committee in order to take the developing world beyond being just raw materials supplier.

Table 2 Materials used in Modern Concrete Technology

Binder Systems	Aggregates	Reinforcing Systems	Admixtures
Portland cements	Natural sands and gravels	Ordinary steel bars	Additives-for example, retarders, accelerators, stabilisers, air-entraining agents, workability
Blended cements	Crushed aggregates	Wire mesh, glass fibres, steel fibres, polymer fibres	
Special cements (with or without admixtures)	Natural light aggregates	Special-purpose	

Cementitious materials, mostly reacting with water	Pyro-processed lightweight aggregates	steel bars and steel cables	aids, water-reducing agents
	Natural heavy aggregates	Pre-stressing systems	Fly ash, silica
	Inorganic and organic wastes	Glass fibre tendon systems	Polymer dispersions, epoxy resins, emulsions
	Special inorganic and organic products		

Source: ATAS Bulletin Issue 5 May 1988

Concluding Remarks

The total volume of raw materials obtained from developing countries as a group may not decrease significantly in the near future. However, the wider range of choice being developed enables the buyers rather than the suppliers to control the prices. In addition, any political advantage enjoyed by the developing countries as a result of raw materials reserves will be reduced.

In order to address these problems, the following steps are recommended:

1. The developing countries should increase the consumption of their raw materials for the provision of services and production of goods.
2. Each country should establish an organisation to coordinate activities in the area of raw materials development. The organisation should take stock of the raw materials and the various industrial and R & D activities in the country. The available technologies for raw materials processing and the local capability for process equipment fabrication should also be documented.
3. Small scale materials processing industries should be established by the government to stimulate entrepreneurs to venture into unexploited areas of raw material processing.
4. Where feasible, indigenous raw materials processing technologies should be upgraded to industrial scale.
5. Attention should be focused on relatively simple raw materials processing technologies that are of importance to each country. For example, in Nigeria, research activities in concrete production technology may yield wide range of

products with various properties. The utilisation of smaller-diameter wood and coarse chips from waste wood or old wood for production of plywood, fibreboard and particle board provide another fertile area for development.

6. Though Governments may not be able to set up Materials Research Centres immediately, the relevant departments in the universities may be upgraded to address research activities in this area. There is also the need for researchers in the universities and other R&D institutes to share facilities.
7. Manufacturing industries in each country should be compelled to use local raw materials where found to be of good quality.
8. Government should introduce policies which oblige all industrial establishments to define deletion programme for their raw materials.
9. Interaction between industry and Research Centres should be intensified for substitution of imported raw materials in order to boost the utilisation of local raw materials.
10. Curricula in the Universities and Polytechnics should be re-examined to ensure that materials process technology is adequately addressed.
11. All developing countries should be committed to the programmes of the Action Committee on Raw Materials under the Group 77 Committee.

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