日本包装学会国際包装セミナー（IPS‘９６）要旨

The Environmental Debate : Recurring Themes and Emerging Trends-An International Perspective

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The modern Green movement arose out of the nature and conservation societies of the late 19th and early 20th centuries. With the rapid industrialization of Europe in thel950s, local residents became concerned about the construction of, for example, nuclear power plants. Protests continued during the 1950s on a project-by-project basis, becoming increasingly critical of the "system" which was perceived as industry destroying the environment with no objection (and often subsidies) from government.

Out of this background the Green Party was formed, achieving considerable electoral success in thel980s. Their declining support inl990 just 3.9% (attributed in part to the fact that the mainstream parties had included environmental policies in their manifestos) was followed by their best ever performance in local elections in 1995 of 10%.

The German Green Party today is the strongest it has ever been. Now less ideological and no longer a fringe party, it could assume a role as the kingmaker in c coalition governments. But to get their support, governments will have to promise to undertake a restructuring of industry /society to make it more ecologically sensitive.

The Greens want society to make visible sacrifices for the sake of the environment. The big question is: will packaging be a focal point of their activities, or (given that the DSD is now running successfully) will they address the really significant environmental issues in German society, such as the use of the private motor car. They will likely push for a tax on CO2 and on virgin raw materials.

Fashions change fast in greenery. Yesterday, the vogue was to proclaim imminent environmental catastrophe. Today it is to dismiss such talk as rubbish. 1995 saw a spate of "green bashing" with the publication of five books critical of environmentalists.

- Life on a Modern Planet by *Richard North*
- Down to Earth by *Matt Ridley*
- Small is Stupid: Blowing the Whistle on the Greens by *Wilfred Beckerman*
- A Moment on the Earth by *Greg Easterbrook*

- But is it true? A Citizen's Guide to Environmental Health and Safety Issues by Aaron Wildavsky

Worthy of note is the fact that all five authors claim to be environmentalists. They are not really anti-Green but post-Green. They are against complacency and over-confidence and are rightly sceptical of dogma. Their message is simple: green campaigners have distorted the truth, told lies and made extreme statements to frighten the public. Greens respond that hyperbole is needed in a market competition for funds.

However, the worthiness of a cause does not justify lying. If the evidence conflicts with the theory, it is the theory which must yield, not the evidence. Closing our eyes to what is there does not make it go away. What environmentalism needs most urgently is more evidence and more research. We need to know what truth there is, if any, in some of the claims being made.

The authors show how the excited predictions of the early 1970s about world famine and exhausted oil reserves were nonsense (proven reserves of oil are now larger than ever before and fleets of alternative fuels are queuing up to take its place).

Ever since Rachel Carson, in her 1962 book The Silent Spring, predicted its imminent extinction, the robin has been America's commonest bird.

In 1983, virtually everybody agreed that one-third of the trees in German forests were dying from acid rain. Not only did far fewer die, but a 10 year, $500 mil. US study concluded that acid rain was not even at the top of the list of problems facing forests, and the alarm spread about acid rain was excessive. Current research suggests that leaf loss in European forests may be due to the increasing density of tress within forests.

The seals of the North Sea were supposed to be dying from pollution in 1989; they were actually suffering from a viral epidemic aided by high population density.
The Braer oil spill in 1994 was supposed to do irreparable damage to the wildlife of Shetland. In fact the effect has been minimal.

The books argue that exaggeration, nationalization and central planning are the enemies of the environment, not the allies. Growth and technology are often the solution to a better environment, not the problem they are frequently portrayed as.

Many of the present problems have arisen because Governments have subsidized industry and failed to make them "internalize the externalities", i.e. Pay for the use they make of the environment to absorb their waste products.

Few local governments change citizens the true costs for waste collection, recycling and disposal, thus providing no incentive for waste minimization and relying on industry funding to subsidize these activities.

Despite the fact that most dire predictions of environmentalists have not come true, Green

groups remain extremely powerful as evidenced by the backdown by Shell in September last year over the dumping of the Brent Spar platform in the North Sea. One of the many lessons of the Brent Spar affair - in which Greenpeace forced Shell to abandon its plans to dump the redundant oil platform in the deep Atlantic - is to underline the vulnerability of international companies to environmental campaigns. It also demonstrates that technical arguments are no match for public gut feelings and sends a confusing message to companies who want to do the "right thing". What do people means by the "right thing" anyway? That which science dictates? What regulators want? What environmentalists value? What the public desire? What consumers would like? Unfortunately, much of the regulation which impacts on the packaging industry is based on false perceptions and myths held by the public and politicians.

It makes no sense to recover materials from the waste stream at any cost, simply because they are physically recoverable or merely to reach targets. It makes no sense to subsidies inefficient markets since to do so prevents sustainable, long-term, competitive markets from emerging. Reaching the recycling targets will not solve any environmental problems. What is required is a better system, not bigger targets.

One of the most encouraging trends over recent years has been the increasing availability of information on packaging, solid waste and the environment. Such information is sorely needed to replace the black hole of ignorance on which most packaging legislation has been based.

One popular myth or recurring theme around the world is that the quantity of packaging is increasing much faster than population and we will soon be buried under a mountain of used packaging. Data to rebut this myth is generally unavailable; the US EPA study is an. exception.

Growth of population from 1970 to 1988
compared to the increase in MSW discards

Population	21%
MSW Discards	38%
Selected Components of Discards:	
Food, yard and miscellaneous inorganic waste	24%
Reading materials	44%
Durable good	63%
Office and other paper	87%
Clothing and footwear	60%
Miscellaneous non-durable goods	47.5%
Containers and packaging	9%

Source: US EPA Characterization of MSW in the United States: 1990 Update 38:46

This data clearly demonstrates that while MSW has increased almost twice as much as population, containers and packaging have actually decreased. The biggest increase has been in non-durable goods such as disposable diapers.

Facts such as these need to be communicated to politicians, policy-makers and the public. It is imperative that legislators and policy-makers have the flexibility to modify their laws and views in the light of facts which were previously unavailable.

Former EPA official Dr. Winston Porter (now a private consultant to industry and government) in a recent report entitled **Recycling at the Cross-Roads** states that "a practical upper limit for a national recycling rate is 33%. A good target for most locations is 20 - 30%". He doubts that the effort to greatly expand curbside programs would be worth the money: "For the people who have a desperate need to feel good, you can always have a drop-off bin".

His study shows that the USA is on a much faster and more efficient track than the Europeans, and is already recycling at a rate which Europe hopes to reach in about five years. Based on his study of German, French, British and European Union recycling approaches, he complied a set of principles.

Firstly, deal with all the trash in MSW, not just the one-third which is packaging. Many non-packaging items are recycled in the US, including newspapers, office paper, telephone directories and yard wastes.

Secondly, set overall recycling goals, not material-specific mandates. Recycling applies very differently to various materials and products. While it makes sense to recycle aluminium cans because of the large amounts of energy required to produce them, plastic wastes are lightweight, thus making collection and sorting expensive. Since plastic packaging requires very little energy and raw material to produce, it has less value for recycling.

Thirdly, don't set unreasonable recycling rates and dates. The Germans have shown how expensive it is to set high rates (70%) to be reached in short time frames (about 3-4 years). Their overall recycling costs are about US$500 per ton versus US$150-200 in the US.

Fourthly, leave the basic MSW collection and sorting operations with municipalities. As the Germans have illustrated, it is extremely expensive to operate public and private collection systems side-by-side. Industry's role is primarily to recycle collected materials, and billions have been spent in doing so in the US.

One important emerging trend is the increasing data on the actual costs involves in diverting household waste from landfill. Many local governments have introduced curbside collection and other diversion schemes without any idea of the likely costs. When they find out just how expensive such schemes are, they then turn to industry for funding. Having good data on actual costs might dissuade municipalities from introducing such schemes, or at least bring some realism to their discussions.

An emerging trend is the scientific studies by universities and research institutes into the environmental and economic limits to recycling. For example, listed below are the titles of seven papers presented at the international recycling congress R'95 held in Geneva last year.

- Ecological limits of recycling - Germany
- Environmental impacts by disposal processes - Denmark
- Environmental assessments of products and recycling of packaging - Switzerland
- Ecological and economic limits on recycling - Switzerland
- Ecological, economic and technical limits to recycling of packaging material - Switzerland
- Costs and benefits of recycling - UK
- Is separation of waste always justified? - Switzerland

While most of the studies arc at a preliminary stage, they suggest that recycling is not always the most sensible valorization technique for packaging material, and that the environmental impacts of recycling are often as great (or sometimes greater) than virgin material production.

As an industry, we should be encouraging similar studies in our own countries.

In discussions about recycling, much is said about "closing the loop", i.e. recycling the used package back into another similar package. Glass and metal package manufacturers are particular exponents of closed loop recycling because it is technologically simple for them to do, and in the case of glass, it is really their only option.

However, it is important to realise that the physical environment (i.e. what we are all working to preserve) is unconcerned with whether the recycling is closed or open loop. What is important are the overall environmental impacts of the recycling processes. If open loop impacts are lower than closed loop, then open loop recycling should be promoted.

Moves by governments and some sectors of the packaging industry to set mandatory recycled content in packaging is nothing more than an interventionist, "command-and-control" attempt to develop markets for recycled materials in the hope of making curbside recycling financially viable. While the glass, metal and PET packaging manufacturers can achieve high recycled content, there are technological and safety reasons which preclude paper and other plastic packaging in direct contact with food from doing the same.

Also, since the recycled content of a package cannot be measured for most packaging materials, mandatory recycled content is unenforceable.

An emerging trend is the move towards green or environmental marketing. Marketing gurus are convinced that this is a huge business opportunity as the following quote from Tom Peters (co-author of In Search of Excellence) demonstrates:

"The environment is the biggest business opportunity that confronts virtually any human being in business. The greening of the market is a 'remarkable, perhaps once-in-a-century opportunity 'for the corporation wise enough to seize it. "

At Terra Pak we believe that it makes sense to try and obtain a competitive advantage from the environmental profile of our packaging systems.

Further support for green marketing is provided by Professor Philip Kotler whose classic textbook **Marketing** (now in its 6th edition) is still being used in universities over 35 years since the first edition appeared.

Business have recently embraced 'customer-centered marketing' and ' environmental marketing'. Consumers have been crying for a better environment and smart marketing companies have already been responding - and earning money in the process. "

The message is clear: environmental advantages are competitive; the environment is a business opportunity; environmental marketing is the way of the future. The only caution I would offer is that environmental marketing claims be based on facts rather than fantasies dreamt up during the excitement of a marketing strategy meeting.

Another emerging trend is the increasing demand by consumers for verification of the eco-performance of a product or its packaging, life cycle analysis is one tool which has a role to play here. However, trying to summarize LCA results into meaningful, balanced statements is an incredible challenge for technical and marketing staff alike.

I believe increasing use will be made of environmental audits to quantify the emissions to air, water and land from specific manufacturing sites. These will then serve as benchmarks, and through continual improvement, the emissions will be reduced over time.

In addition, more and more companies are installing environmental management systems which will be able to be certified against ISO 14001 when it is released later this year. It is important for the packaging industry to enthusiastically embrace environmental audits and EMSs, not only to show its commitment to reducing environmental impacts, but also to turn the spotlight away from post-consumer packaging towards a life cycle view.

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IBM Status of Environmental Issues in Packaging

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MISPERCEPTIONS

Since packaging represents one-third of municipal solid waste it has gotten a lot of attention in re-cent years as the environmental "bad" guy. The most adamant critics would like to eliminate packaging altogether, while others push for recycling everything. A recent study by the United Kingdom Center for Economic and Environmental Development came up with several interesting conclusions related to packaging and it role in our everyday lives.

- The public pays disproportionate attention to packaging as an environmental issue. "Casual and pejorative use of the term 'over- packaging' often stems from a lack of understanding of the purpose of packaging and the processes involved in its selection."
- Consumers are unaware of the role played by packaging upstream, and their perceptions can be misguided. But "they are unlikely to purchase a product if the packaging has failed."
- With constant pressure to drive down production costs, "it would defy economic logic for a company to package a product purposely in excessive materials."
- New laws should be based on fact, not supposition. "Much of the legislation reflects a kneejerk response to a perceived environmental problem. Policy should be chosen for its overall effectiveness and not just for its ability to address single, high profile concerns."

Packaging selection involves trade-offs between numerous environmental and marketing criteria. For example, a product which is susceptible to theft or tampering may require security measures be incorporated into the package design. If everyone agrees that preventing product theft or tampering is a legitimate packaging function, then the additional resources to provide this function are justified.

Market forces should encourage all participants in the supply chain to minimize production costs, including the costs of packaging. If the market works effectively, only the necessary packaging for a given product will be used.

REALITY

Studies have shown that in less developed countries packaging actually reduces solid waste and

improves the standard of living because it allows food and products to be shipped from farms and factories to the consumer virtually free of damage or spoilage.

Eliminating packaging is not the answer. Neither is 100% recycling. Given today's technologies, it is not practical to recycle all packaging materials due to contamination, degradation of materials, small volumes and lack of commitment by the consumer in collection.

Source reduction is a continuing trend in packaging. Lightweighting is good for the environment and also makes good economic sense for industry. Less material usually means lower costs. Many companies are implementing environmental packaging designs and saving money at the same time.

Recycling is steadily expanding and brings in line the chain of independent activities necessary for success. Tens of thousands of communities around the world have or are implementing curbside collection programs or local drop-off centers. At the same time numerous companies are finding that recycling packaging materials from their manufacturing processes also pays big dividends and reduces costs.

Governments around the world are passing new non-uniform and often conflicting legislation. Many countries such as U.S., Germany, the EEC, Canada and Japan, are all creating legislation which is seriously compounding the problems and exposures of international companies. Outlined below are IBM's efforts to address these problems.

IBM 's ENVIRONMENTAL PACKAGING PROGRAM

SUMMARY:

Environmental issues have and will continue to influence the packaging materials and design characteristics for IBM products, parts and supplies. In late 1990, IBM's Worldwide Distribution Engineering Services department, (WDES) located in Research Triangle Park, North Carolina was assigned the responsibility to implement a formal environmental packaging program for the IBM Corporation. The first task was to develop a worldwide environmental packaging strategy which would meet the general objectives of reduce, reuse and recycle. An Environmental Design Guide was written to address these environmental packaging issues being identified by local, state, federal and international governments. The Guide has been distributed to all IBM worldwide packaging organizations to assist them in lessening the impact of IBM's packaging on the environment.

The environmental concerns addressed are:

- Process biproduct problems (e.g. CFCs, dioxins, heavy metals);
- Methods for reducing the amount of packaging required;
- Increasing reusability of packaging designs;

- Refurbishing and reusing versus purchasing new (e.g. pallets);
- Improving recycling through use of proper symbology identifications;
- Improving recycling by requiring more recycled content.

WDES has also developed a Corporate Bulletin and three engineering specifications as additional tools to assist in the uniform implementation of IBM requirements:

- Environmental Packaging: Requirements for Products, Parts & Supplies;
- Expanded Packaging Materials: Prohibited Blowing Agents (for CFCs);
- Packaging Materials: Restricted Heavy Metals;
- Recyclable Packaging Materials: Selection and Identification.

These specifications are identified on packaging engineering drawings for procuring packaging materials and electronic parts from IBM suppliers.

WDES has also developed environmental packaging initiatives with planned compliance schedules worldwide to insure improvement activities are uniformly implemented. Listed below are the initiatives that have been implemented thus for.

- Eliminate " CFC" blowing agents from foam products
- Control "heavy Metals" in packaging
- Added recycle symbols to cartons
- Added resin codes to plastics
- Changed from white corrugate to kraft color
- Eliminate "PBBs/PBBOs" in plastic packaging
- Extend above requirements to parts suppliers
- Minimum 50% recycled content in corrugate
- Minimum 15% recycled resin in polyethylene foam
- Minimum 25% recycled resin in polystyrene foam

To help encourage implementation of the above initiatives, an internal IBM competition was started by asking our worldwide IBM packaging engineers to submit their environmental projects, which conformed to the corporate strategies, to WDES for evaluation. Based on how well the projects met the objectives of the guide and initiatives, a winner was selected from the submitting sites. The winning site is awarded a site plaque and each individual who participated in the implementation of the environmental packaging projects is also given a plaque. Our Rochester, Minnesota manufacturing site won the award in 1989 and 1990. They were co-winners in 1991 along with our Research Triangle Park, North Carolina manufacturing site. In 1992 our San Jose site won the award. In 1993, 94 and 95 our Greenock, Scotland site won the award. This internal award has been the spring board for these sites to pursue additional awards. In 1993, Rochester won the Minnesota Governors Award for Excellence in Pollution

Prevention and in that same year the San Jose packaging engineering department won IBM's prestigious "Environmental Affaire Technical Excellence Award. " From 1990 to 1995 over 250 environmental packaging projects have saved IBM in excess of $90 million.

GOALS:

IBM has three key goals for 1996 to reduce, reuse and recycle as much packaging material as is economically and technically feasible. The goals are:

- Increase product and part ruggedness in order to reduce the need for excessive packaging protection.
- Continue to create tools and provide information which will assist IBM packaging engineers in their continuing effort to reduce, reuse and recycle.
- Update environmental packaging symbols to be consistent with new EU symbols.

ORGANIZATION :

- WDES, IBM's packaging engineering competence center, continues to set and drive IBM's efforts to implement environmental packaging. Each year the group sponsors an internal competition among all manufacturing sites to recognize environmental contributions with a focus on source reduction.
- Individual manufacturing sites have established working groups which meet periodically to identify, analyze and track environmental packaging improvements for suppliers and interplant shipments.
- WDES works closely with our Corporate Environmental Programs group to evaluate strategies in the environmental area.

ACTIVITIES :

- There were approximately 150 environmental packaging projects implemented since 1990 at IBM sites around the world. These projects covered reduction, reuse and recycling.
- New products are being tested in our packaging labs to increase their ruggedness, thus reducing the need for packaging. As ruggedness increases, shock absorbing foams are being replaced by corrugate and recycled paper pulp cushion designs.
- Conservative measurements indicate that approximately one million cubic feet of packaging materials were diverted from landfills over the past few years. This figure does not include manufacturing process related packaging material diverted from land fills. These materials are collected, sorted and recycled at approximately a 70 percent level.
- IBM has been part of several benchmarking studies which included comparison of environmental packaging, and IBM was rated as one of the best.

BENEFITS :

- Over $90 minion saved from 1990 through 1995.
- Better positioned to meet current and future regulations.
- Increased employee awareness of the need to be involved in helping reduce solid waste.
- Improved customer satisfaction by demonstrating our commitment to reducing packaging's environmental impact.

PROBLEMS :

- The hostile environment in which our products are shipped plays an enormous part in dictating the amount of packaging protection required to get our products delivered defect free.
- Conflicts in local, state, national and international regulations continue to cause major problems and increased manufacturing costs.
- Packaging can not be continually source reduced without compromising safety and package integrity.
- Being competitive in the market place requires that environmental packaging projects be cost justified or at least break-even.
- The transportation industry needs to become a partner in the effort to reduce packaging.
- Most consumers are not knowledgeable and/or motivated enough to recycle our type of packaging.

FUTURE:

- Continue to be environmentally proactive.
- Continue IBM initiatives to increase minimum recycled content in our packaging materials.
- Provide IBM customers with packaging that is locally 100 percent recyclable.
- Complete the development of packaging material tracking and reporting program called TRTRAK.
- Complete the integration of environmental packaging principles and goals into the product development and manufacturing processes worldwide.

CONCLUSION:

A free market relies on consumer choice, with nearly all forms of consumer demand being regarded as legitimate. If laws are passed that circumvent this principal they are almost always doomed to failure or expensive means are used to prop them up. One only needs to look at some existing programs to see how expensive this kind of folly can be. Finding the best and least expensive alternative requires government and industry working together.

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Quality Protection of Food by Packaging

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One of the main purpose of packaging is to protect the quality and the quantity of packed goods. In the case of foods it means that the well constructed package keeps the sensory and nutritive value of food from the procedure of packaging to consumption.

The quality changes of foods and the «quality” of packaging has a stochastic relationship, since the quality changing of food depends on the chemical components, physical and biological state of food items. Consequently the rate of deterioration determine the time of keeping quality including the shelf-life of packed foods.

It is a well-known fact that the ,,quality" of the packages has a tight correlation with the barrier properties of the packages and the packaging materials. The barrier properties of packages depend on the forming and sealing technology and in the case of packaging materials it is the function of morphologic structure what is especially effective to the polymer base packaging materials.

Our studies performed had two main lines: we analyzed the causes of food deterioration using chemical, physico-chemical, physical and sensoric methods and we investigated the barrier properties of packaging materials first of all on polymer base. For conclusion we searched correlations between the rate of food deterioration and the protective effects of packages.

Quality changes of food

Quality changes of food usually have a negative character - apart from some exceptions as the ,,ageing" of viticultural products or of cheeses - what results the deterioration of the food. Obviously, changes deriving from the insufficient operation of technologies do not cover the phenomena.
Chemical origin of quality changing has direct and indirect effects. Direct effect is the oxydation of food components. The very significant changing is the rancidity of foods. We can also realize the non-desirable enzyme activity what changes the food matrix and in that the level of component concentration. Indirect effect is for example the catalyses of heavy metal molecules or light as energy source of quality changing reactions.

Physical origin of quality changing are mainly caused by the micro- and macro-climate differences inside and outside of package. It means that the water content of food can be changed according to the changing of relative humidity. It is a direct effect what also keep in hiding an indirect effect when the aroma components are evaporating with water vapour as aseotropic molecule mixture.

We have to mention the direct effect of temperature on food quality. The texture and theological behaviour may change according to the fluctuation of temperature e.g. during storage, transportation and selling.

The strange material penetration is another important group of deteriorative physical changing. The various auxiliaries of packaging material production including the solvents of printing are the sources of strange materials. In extreme cases monomers and/or oligomers may also penetrate into the packed food.

Microciological origin of quality changing is very frequent reason of food deterioration. The quality changing is caused by the multiplication of microorganism in the food or by infection of microbes and as a result of their activities carbohydrates, proteins and lipids may decompose in food. The insufficient water activity may increase the activity of microorganisms and the consumption of food will be restricted. The aseptic technologies and the vacuum and inert gas atmosphere packaging can also reduce or stop the microbial activities.

Quality protection by packaging

According to our observation it may be stated that the reactions effect on the quality at same time or - in most cases - parallely in space and time and in addition they usually interact with each other. The reactions of deterioration often take place with quality changes induced by the propagation of food micro flora, too.

First of all for the improvement of quality protection by packaging the barrier properties of packaging materials were studied. The consideration based on the following equation for the quantity determination of permeating gases and vapours when the temperature is constant.

$$Q = \frac{PA\,\Delta pt}{l} \qquad (1)$$

where Q = quantity of permeating materials, P = permeability constant, A = active surface, Ap = pressure difference of two sides of package, t = time of permeation (storage) time, 1 = thickness of packaging material.

In the above mentioned equation the permeability constant (P) is in ratio with the diffusion (D) and solubility (S) coefficients, with other words the quantity of material transmitting through a membrane or foil (of unit surface and thickness in a time unit at a given temperature and pressures differences) will be equal with the product of diffusion coefficient (on surface and time unit) and the solubility coefficient (of the mass unit of material transmitting through a unit volume of the membrane).

$$P = D\,S \qquad (2)$$

Analysing the possibilities of food quality protection and the improvement of it by packaging it may be stated that the interpretation of Equation 1 helps us in this matter. The key factor is the permeability constant (P), because the storage time is usually given (shelf-life), the changing of the active surface (A), and of the thickness of the packaging material (1) is very limited regarding to the aspects of package design, furthermore the modified atmosphere can influence the value of Δp, but it needs a special technique. The components of Equation 2 call our attention to the importance of morphologic structure of packaging materials in the case of polymer foils and containers.

Effects of packaging material structure

Most of the solid polymers consist of ordered and disordered or with other words crystallic and amorphous parts. Accordingly, when polymer foils as packaging materials are examined, the ratio of crystallic and amorphous parts have to be considered as the basic structural characteristic significantly influences the quality of the polymer. When the permeability is tested, especially important is to consider the ratio of amorphous and crystallic parts because a close correlation exists between the micromorphology of the polymers and the barrier behaviour.

Experiments prove that three groups of solid polymers show especially good correlation between the crystallic (ordered part) content and the permeability: these are polyethylenes, vinyl-polymers, or copolymers and fluorized hydrocarbons.

Experiments also proved the correlation between the crystallic content of polymers and the permeation of gases or water vapour. The permeability of the polymer has a linear correlation with the amorphous content as it is described by the following equations:

$$P = D S_a X_a = P_a X_a \qquad (3)$$

where

$$S = S_a X_a \qquad (4)$$

and

$$P_a = D S_a \qquad (5)$$

where Xa shows the ratio of amorphous part in the polymer (index ,,a" marks the behaviour of the amorphous part). It means that the value of permeability constant depends on the quantity of the amorphous (or the crystallic part) and in many cases the specific volume gives a good information on the crystallic content in the same polymer (e.g. polyethylenes).

The crystallic part of the plymer is practically not active for the permeation and there is no direct effect to diffusion in the amorphous part, but the dispersion of crystallic agglomerates can effect on the quantity of the permeated molecules. This means that the actual free path for the diffusion of molecules is longer than it should be calculated from the thickness of the membrane. Thus, to the mutual effect of these factors the value of the diffusion coefficient (D).

is smaller than it would be in case of the completely amorphous polymer (Da). It may be described by the following equation:

$$D = \frac{Da}{\tau} \qquad (6)$$

where τ is the factor of proportionality, it expresses the increased free path length of the diffusing molecule which derives from the dispersion of the crystallic parts in the membrane, too. Results also unambigously prove that the quantity of a given permeating gas has a linear correlation with the ratio of ordered (crystallic) and/or disordered (amorphous) parts.

It may be stated from the above that the quantity of the permeating material may be well estimated by calculation if the structure of the polymer and the permeating molecule(s) are known. This means, that at a given packaging material, for example the change of the moisture content in the packed food may be predicted if the storage conditions are known (temperature, humidity)

Effect of temperature

The quality changing of foods and the permeability of polymers depends on the temperatutre since they change exponentially when it increases or decreases as it follows:

$$k = k_0 e^{-\frac{E_a}{RT}} \qquad (7)$$

$$P = P_0 e^{-\frac{E_p}{RT}} \qquad (8)$$

where Ea = activation energy of reaction, Ep = activation energy of permeability, R = universal gas constant, T = temperature in K. For the Ea or Ep calculation it can be use a transformation to log P and 1/T.

It may be stated that the effect of temperature is important from the aspects of the food deterioration and of the permeability of packaging materials. Consequently the optimization of temperature effect has a basic interest.

Conclusion

The quality protection plan of packed food needs information about the barrier properties of packaging materials and containers, the expected keeping quality or shelf-life of food, and the storage conditions as temperature, relative humidity and illumination. The rate of quality changing of packed food depends on the barrier properties of package and in addition there is a proportional relation between the package form or container - it means the active surface size

and the wall thickness -and the quality protection. It must be emphasize that the barrier behaviour and the convertibility of the packaging material is determined by the microstructure. The quantity of strange materials also influences the rate of food deterioration and/or the sensoric quality of food. The hygienic state of packed food and the storage conditions are determinants. The quality of packaging can not compensate the effect of temperature on the food deterioration. The behaviour of the critical properties of food also depends on the temperature. Consequently the quality protection of food requires comprehensive investigations and tests because the task is multidisciplinary.