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Workshop on Fermentation Alcohol for Use as
Fuel and Chemical Feedstock in Developing Countries
Vienna, Austria, 26 - 30 March 1979

MISUSE OF ALCOHOL FROM AUTOMOBILE FUELS AND PREVENTIVE MEASURES*

by

O. A. Forsander**

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At this workshop we shall hear much about the benefits the production of cheap fermentation alcohol can have as an alternative to gasoline. I am sure that this alcohol could make life easier for many people, especially in developing countries. As a fuel, it can make heavy physical work easier and increase productivity.

It is common that the consequences of introducing a new technology are not wholly good, and I think that this could be the case with this alcohol if we do not immediately start taking steps to prevent the ill effects that introducing cheap alcohol can have in districts where such alcohol has not been accessible before. Often it has not been possible to foresee the negative consequences of a new technology until it has been used for some time and we get some experience of the bright and dark sides of the coin. This was so, for example, when the first biocides were put on the

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If inexpensive alcohol can be produced and becomes widely used for powering motor vehicles it is almost inevitable that problems will arise concerning the use of this alcohol for human consumption. That this will occur can be concluded from what has happened previously in countries in which alcohol has been added to gasoline for use in cars. During and after the last war in Europe fermentation alcohol was added to gasoline in some countries. It soon became common knowledge that the alcohol could be easily separated from the gasoline; consequently despite the residual gasoline flavor in the alcohol, misuse became rather prevalent. It seems quite likely that this will also take place in the future, everywhere fermentation alcohol is used as an alternative for gasoline, unless preventive measures are taken.

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It is, therefore, important that when we consider the benefits to be derived from the wid spread production of alcohol in small plants, we also consider the possible problems this alcohol will bring with it, and discuss how we can control or minimize the misuse of this alcohol. There are ways by which misuse can be controlled at least to some degree. One way involves legal restrictions and tight police control. Another way is by adding compounds to the alcohol which make it difficult or impossible to be consumed by human beings. Among the various alternatives for the latter strategy there are some which appear to offer the best chance for coping with this problem.

market. At first there was an overenthusiastic optimism in favour of these compounds, but fairly soon it was found that they also had a bad effect on the balance of the environment, and nowadays there are more and more people who are against their indiscriminate use.

In introducing fermentation alcohol as a cheap alternative for gasoline we are in a better position than those who once introduced biocides to the farmers. We can foresee what will happen if no preventive measures are taken, and we can at least to some extent counteract the misuse of this alcohol. Cheap industrial alcohol has long since been used for technical purposes, and it has also been misused by man. We therefore have experience both of producing technical alcohol and of attempts at preventing its misuse, and we also know what an unrestricted misuse will bring with it for the misuser himself and for his family.

Misuse

Technical alcohol has been misused wherever it has been available, even when society has tried to control its sale and to make it as undrinkable as possible. It seems that technical alcohol is most misused in countries where beverage alcohol is expensive and where home production is not traditional. Some years ago in Finland the price of vodka, which was the most common alcoholic beverage, was 40 times higher than the price of a commonly available technical alcohol. It is usually the poor, more or less homeless alcoholics who misuse it.

As fas as is known, there is no literature on how this misuse varies in different countries, although for Scandinavia, and especially for Finland, there are some figures on the consumption of industrial alcohol. Some years ago it was reported that the number of misusers in Sweden was about 4000. For Finland it has been reported that of the 3 000 000 liters of technical alcohol that were produced, 50 000-200 000 liters were

consumed illegally. This is a high proportion. The number of misusers has now gone down in both Finland and Sweden, largely as a result of the improved economic situation of potential misusers. Another factor influencing misuse is that the alcohol is now much more effectively denatured than it was 10 years ago, which makes it difficult to consume The introduction of new chemicals for denaturing technical alcohol has drastically decreased the number of people arrested by the police for drunkenness from the consumption of technical alcohol.

If alcohol is mixed with gasoline it is an easy task to separate them again. Anyone can learn to do it in a minute, and, if alcohol is used neat, it will be even easier to obtain and consume. The use of technical alcohol as an alternative for gasoline means that it will be easily available in places where perhaps before it was difficult to obtain, and this could increase the number of misusers enormously. And what is especially dangerous is that this alcohol is hard liquor. The effect will be quite different if a person drinks the same amount of an arbitrarily diluted alcohol as he had previously drunk homebrew or wine, and could be still worse if he fortifies his homebrew with the alcohol. It is only too easy to imagine what may happen when he then drives the car or bus from which he has taken the alcohol.

Toxicity

Technical alcohol produced for use in internal combustion engines does not have to be purified in the same way as beverage alcohol; quite other criteria apply than those of taste and aroma. It can contain all types of compounds that are present in the fermentation mixture as long as they do not damage the motor. Some of these have a bad taste and, depending on the raw material used, even toxic compounds can be present in the final product. How pure the alcohol is depends mainly on the efficiency of the distillation process.

The congeners present in the distillation product are usually not so poisonous in the concentrations at which they naturally occur, although they can be very toxic at high concentrations. We should be aware, however, that all alcoholic beverages contain highly dangerous compounds. This compound is the ethanol itself, compared to which the danger of the congeners is small. The congeners consist of higher alcohols, esters, fatty acids, aldehydes and ketones, and consumed in larger amounts they may damage the body. Nevertheless, the main component, the ethanol, also has a damaging effect, and being present at so much higher levels than the other components, it will be the dominant toxic substance. It can be mentioned that whisky, for example, contains more than 250 identified chemical compounds. A raw distillation of alcohol for technical use would contain a much higher proportion of impurities than beverage alcohol, but the ethanol will generally still be the most dangerous component.

A possible exception is when the final distillation product contains a high level of methanol. This can occur if a raw material is used from which much methanol is produced during the fermentation or if methanol is present as such in the raw material. A product containing more than 5-10 % methanol cannot be consumed without very serious consequences. In most cases it will result in blindness or death.

Acute consumption of small amounts of alcohol is not so dangerous as a continuous use of alcohol containing methanol. A Swedish study has reported the consequences of prolonged use of technical alcohol containing methanol. These persons had used a technical product for some weeks and were brought to hospital for treatment. If they had not been treated for methanol intoxication their lives would have been in danger. Methanol is especially harmful when a person drinks it with ethanol for a long period. Ethanol prevents methanol from being eliminated and therefore

methanol accumulates in the body. As long as ethanol is present in the body there is no problem, but methanol oxidation starts as soon as all the ethanol is metabolized. During this oxidation a toxic compound is formed that can so affect the structure of the eye that blindness results, or can disturb other organs and cause death.

It is possible that other harmful compounds than methanol can be accumulated when impure ethanol is consumed. The effects would be seen only after long-term consumption, and so far we have no experience of this.

Prevention

How can we set about preventing the misuse of fermentation alcohol used as fuel in cars, buses, tractors and motors almost everywhere and which is easily accessible? To some extent this could be done by policing in the same way as other industrial alcohols are regulated. A strict control of alcohol fuel and high fines for its consumption would have at least some effect. The control should cover not only the consumption of the alcohol but also its production and all steps in its distribution before it is used as fuel. The effectiveness of this supervision will probably be related to the effectiveness of other police measures in the area. In some places it will be good and in others it will not work. It will be especially difficult to control misuse if the production and use of the alcohol take place in an isolated area where people are used to drinking home-made alcohol. Effective restrictions cannot be assumed to be feasible everywhere.

Another way of preventing or reducing misuse of technical alcohol is to denaturate it with some compound that makes it difficult to drink. This measure has long since been used to restrict consumption of many kinds of industrial alcohols. In different countries alcohol has been denatured in different ways, and more than 100 denaturing recipes are

available for different industrial purposes. Even known poisons have been used to prevent misuse. The compounds added to the alcohol are usually chosen according to the application, and it seems that no universal v useful denaturant exists.

A compound selected to make alcohol more or less undrinkable should have at least the following properties. It should prevent consumption even when diluted to less than one tenth of its original strength. It should not impair the technical performance of the alcohol. It should be difficult to remove the compound from the alcohol and its cost should have a negligible effect on the price of the alcohol.

The first requirement is the most difficult to satisfy, as yet no substance has been found that makes denatured alcohol completely undrinkable. Let us consider the properties that potential denaturants could have. They include:

Table 1. Ways of denaturing technical alcohol

1. Toxic compounds
2. Repugnant taste
3. Pharmacological effect
4. Disgusting color

Toxic substances have been used in many countries and are probably still used in some places. Even cyanide has been added to industrial alcohol to prevent misuse, and methanol has been left in the alcohol or added after distillation. These products will cause death to the consumer and those persons who handle the alcohol have to know that. It is a heavy responsibility to denature alcohol with such poisons.

Methanol may well be used as an alternative for gasoline in northern parts of the world where there is a shortage of carbohydrates for fermentation, while in warmer areas, where sucrose and starch are easier

to produce, ethanol would be usual. It is possible that in some areas both may be used side by side, and here it can be expected that methanol poisoning will occur when a person used to drinking fuel ethanol instead takes fuel methanol. The taste of the two alcohols is not so different, especially if they are mixed with some flavoured diluent.

The most commonly used compounds for denaturing alcohol are currently those that give it a repugnant taste. In Scandinavia a compound with the trade name "Bitrex" is used (benzyldiethyl[(2,6-xylylcarbamoyl)methyl]-ammoniumbenzoate). It has a very bitter taste even at high dilution. Some bitter tasting ketones and the bitter sucrose octaacetate, quassin and brucine have also been used. It is often important that denatured industrial alcohol does not have a bad smell, and for this the bitter tasting substances are useful. On the other hand, foul smelling compounds should be effective in preventing misuse if the legitimate use of the alcohol allows it. Compounds to which we have an inborn aversion could be especially effective for this purpose. It may be possible that such compounds could be useful for denaturing fuel alcohol, although special refuelling arrangements may be necessary if the additive is too effective!

Compounds with pharmacological effects have frequently been used for the denaturation of industrial alcohol. These compounds are drugs that disturb some physiological balance in the body, producing for example diarrhoea, vomiting or a unpleasant feeling. The first compounds used were such that produced diarrhoea. Coloqynth, an extract from an African citrus fruit, has been used. Another drug is crotonaldehyde, which has a strong pharmacological effect but which can be dangerous to the consumer. It also has some negative technical properties. The disadvantages of these types of drug is that they work not immediately, but only some time after consumption. There is no rapid warning; the consumer simply has to

learn that the product cannot be consumed. Compounds that produce vomiting are quite effective for denaturing. Some alkaloids, such as emetine and cephaeline hydrochloride, have been used. They act soon after consumption and prevent a further intake. Those drugs can, however, be fairly toxic, and they are expensive.

There is one class of drugs that has never been used as denaturants but which theoretically would be very effective. They are compounds that taken together with alcohol give a shock effect, the same type of shock that Antabus gives. The effect would occur immediately after the consumption and would discourage a further intake. Some compounds with this effect are known and more could easily be found. As with the other pharmacological drugs toxic effects could hardly be avoided.

Giving the alcohol an unappetizing colour would have some effect on consumption. Moreover, it would identify the product as being intended for motors and not for consumption, and would help the police control its use.

There exists an ideal way of denaturing alcohol, namely by adding a drug to the alcohol that prevents intoxication. There would be little point in consuming the alcohol if the desired effect were missing. At present such compounds are known, but unfortunately they cannot be used for denaturing because of their pharmacological side effects and their high price.

The ideal material for the denaturation of technical alcohol has not yet been found. This is partly because there has not been felt a great enough need for effective denaturants. Now, however, when it seems certain that alcohol will be produced and used on a scale far bigger than ever before, much more research will surely be done in this area.

Most of the substances mentioned can damage the health of the consumer. Some of them can have a very serious effect, especially after a chronic intake, but this must be balanced against the negative effects of alcohol.

A chronic or even an acute intake of alcohol can have very serious consequences It does not act only n the consumer hi self, but also on his family and others around him. It can spoil not only his own life, but also destroy his family and harm the society in which he lives. It is in this light that we must examine the possible ill effects of a potential denaturant.

Conclusions

Alcohol has been misused as long as man has had the skill to ferment alcohol, and technical alcohol has been misused ever since it became available. If alcohol is to be produced and used as a motor fuel enormous amounts of alcohol will be present around the world, and misuse can be expected.

To give an idea of how much more alcohol will be needed as motor fuel than is at present consumed, it can be mentioned that if Finland were to replace 10 per cent of its gasoline with ethanol 20 times more alcohol would have to be produced than is made now. A complete substitution would need a 200 times greater alcohol production.

If nothing is done to prevent misuse of the fuel alcohol as soon as it becomes available, we can expect trouble. It would be much easier to prevent misuse at the beginning when the alcohol is first introduced than later when people have already learned that the new fuel is drinkable.

My recommendation is that when we plan to produce a cheap alternative for gasoline we should at the same time take care to plan how to control its misuse. Ways of doing this should be seriously considered and research organized.

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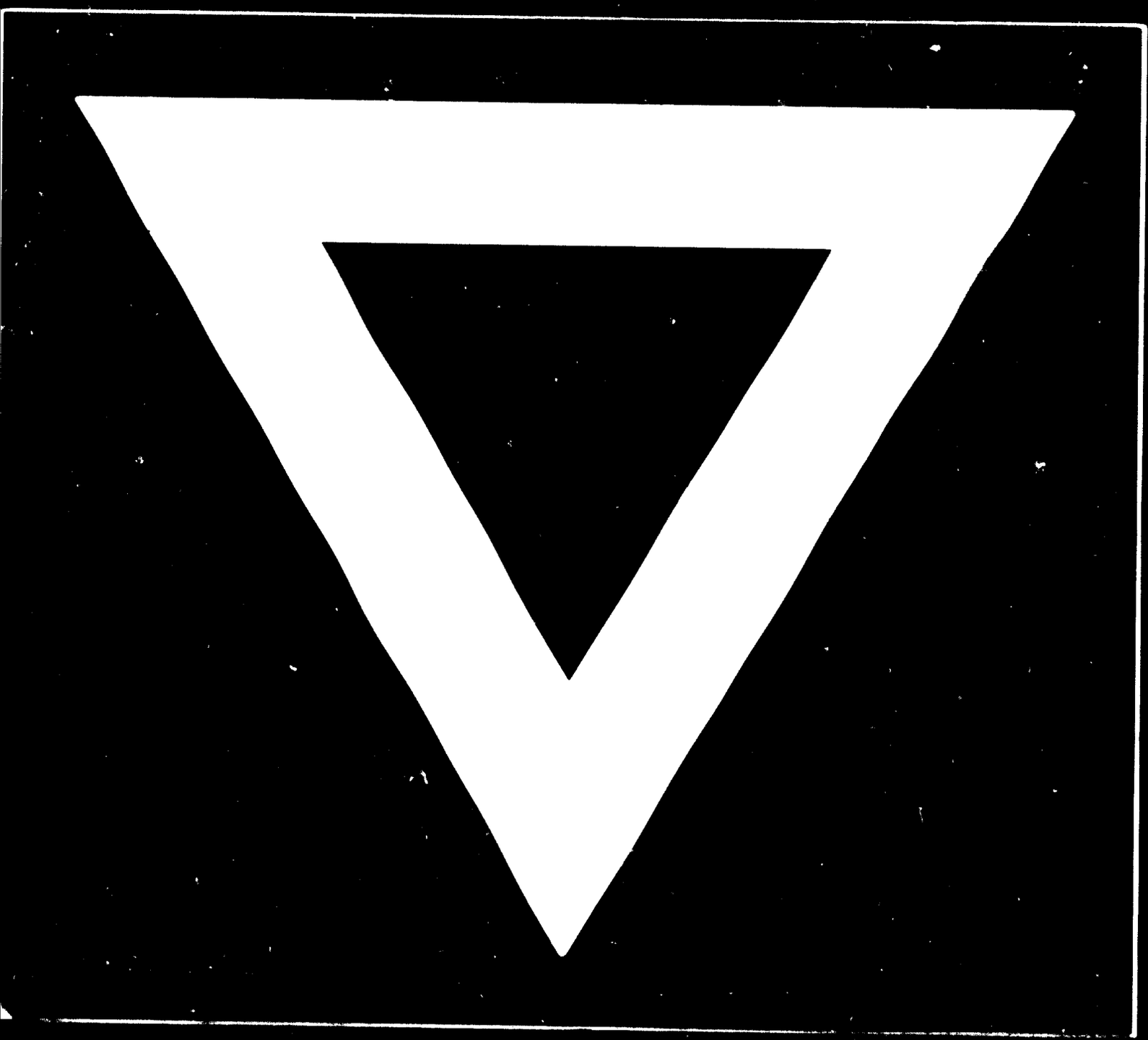

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