Natural nanomaterials as a basic for improving the environmental safety of transport systems

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Abstract. Presented ways to improve the environmental safety of motor vehicles using liquefied petroleum gas and natural nanotubes - chrysotile asbestos. The basic components of petroleum gases, their physico-chemical properties, the percentage of fuel in the gas and the effect on engine operation, and the advantages and disadvantages are designated gaseous fuel. Presented defects in the operation of vehicles with gas-cylinder units associated with the violation of integrity of pipelines and systems. It specifies the requirements for the safe operation of the gas-cylinder cars. The aspects of the use of modern molecular techniques, the use of carbon nanotubes to solve the environmental problems created by cars.

1. Introduction
Perfection of the vehicle is determined not only using modern and advanced materials and technologies, not only equipment of automation and electronics systems, but also fuel-efficient and environmentally friendly, which ultimately characterize and technical and technological level of the country, which produces car.

There are several ways to increase efficiency and environmental vehicles: vehicle computerization, the use of cheap fuel with good performance properties, the use of modern technology for purification of exhaust gases from contaminants.

Affordable method to solve the problem of economic and efficient use of fuel resources while improving environmental performance is to create efficient designs LPG equipments and the widespread introduction of the gaseous fuel on trucks and passenger vehicles.

2. Experimental results
Gas fuel for internal combustion engines in Russia has been applied since 1974. This will save millions of tons of expensive liquid fuels. By creating and using LPG equipment operating characteristics of the vehicle should be different from the base (when operating on liquid fuel) is not more than 7%.

Liquefied petroleum gas - is lighter hydrocarbons, which is obtained by distillation, cracking or pyrolysis (high destructuring) petroleum products. Gases formed in the separation into fractions of associated and natural gases.

Petroleum gases at a relatively low excess pressure (1-2 MPa) and a wide temperature range are in a liquid state. The main components of petroleum gases are propane, butane and propylene.

The physicochemical properties of propane and butane differ significantly. The butane component is the most high-calorie and easily liquefied component, while propane and propylene ensure optimal
vapor saturation in the gas cylinder. Even a slight change in the percentage of these gases in gas fuel affects the engine operating conditions. The composition of the gas fuel is regulated by GOST 57578-87. This standard provides for two grades of gas fuel: winter - PA (automobile propane), and summer - PBA (automobile propane-butane). PA contains 80 to 95% propane, and PBA 40-60%.

A feature of petroleum gases is that they are transported and stored in a liquid state, and are used as fuel in an engine - in a gaseous state.

Gas fuel must have good volatility and miscibility with air. This is necessary for the formation of a homogeneous and high-calorie combustible mixture with high anti-knock properties and a minimum content of resinous substances and mechanical impurities.

The main components of gas fuels (propane and butane) are colorless and odorless. To detect their leakage from the power supply system, odorants are added to the gas - substances with an unpleasant odor. Ethyl mercaptan is used as an odorant. This leads to the fact that the smell of gas is already felt at 0.5% by volume. Small amounts of odorants are completely harmless.

At atmospheric pressure, petroleum gases are non-toxic due to poor solubility in human blood. But, mixing with the air and getting into the human body, the components of the gas mixture reduce the oxygen content in the blood. Propane-butane mixtures, pouring out of the container in the liquid phase, evaporate, taking away heat, therefore, liquefied gas, getting on the human body, can cause frostbite.

An important advantage of gas fuel is its relatively low cost.

The operating time between overhauls of an engine running on liquefied gas is increased by 1.5 times compared to engines running on liquid fuel. Gas fuel does not wash off the oil film from the cylinder walls, which leads to improved lubrication conditions for the cylinder-piston group, does not give carbon deposits and varnish deposits in the engine and power system. When the engine is running on liquefied gas, the phenomenon of engine oil dilution and its contamination with coking products and other contaminants does not occur, which leads to an increase in the frequency of oil and oil filters change. The service life of spark plugs is significantly increased (up to 40%).

The octane number of gas fuel is in the range of 95 - 110 units. This makes it possible to use it on engines with high compression ratios (up to 12).

A huge advantage of gas fuel is its high environmental friendliness. Controlled toxic constituents in exhaust gases are significantly less than in gasoline engines: carbon monoxide (CO) by 3-4 times; hydrocarbons (CH) by 1.2-1.4 times; nitrogen oxides (NO) by 1.2-2 times. There are no harmful lead compounds in the gases. But these indicators are achieved due to the professional regulation of the gas supply equipment and its correct operation.

The combustion rate of the gas-air mixture is much lower than that of the fuel-air mixture. This leads to a noticeable decrease in engine noise (up to 10 dB), the engine runs smoother. This reduces the load in the crank mechanism, increasing its resource.

But not everything is so good. The use of gas fuel leads to a decrease in engine power by 5-7%. The reason is the lower heat of combustion of the fuel, a decrease in the filling factor and the speed of propagation of the flame front in the engine cylinders.

The starting qualities of a cold engine running on gas fuel at positive ambient temperatures and when the temperature drops to minus 5°C does not differ from starting the engine when operating on liquid fuel. At temperatures below minus 5°C, starting is difficult. It is usually recommended to start the engine with liquid fuel at low temperatures, and after warming up, turn on the power from the gas cylinder unit. A warm engine starts as if the ambient temperature is positive.

When operating vehicles with gas-cylinder installations, most of the defects are associated with leakage of pipelines and systems or with ruptured membranes. The appearance of internal depressurization in gas equipment, in contrast to gasoline equipment, causes a decrease in the operational properties of the vehicle and reduces the safety of operation. Efficient and safe operation of gas-cylinder vehicles requires an integrated approach, including, first of all, the development of gas-cylinder valves that are simple in design and reliable in operation. Secondly, the creation of a network of specialized enterprises for the installation of gas equipment and its technical support. But the most
important thing is the training of highly qualified specialists of all levels, capable of ensuring competent operation and repair of equipment.

To purify exhaust gases from harmful impurities, it is advisable to use modern molecular technologies. Nanotechnology is little researched. The main discoveries predicted in this area have not yet been made. Nevertheless, the ongoing research is already showing good results. Nanotechnology is the next step in the development of high-tech industries; nanotechnology is the future in many areas of science and technology.

In developed countries, the results of work on nanotechnology are of great importance, which leads to the development of many programs for their development at the state level.

The technology for controlling the structure of matter from the atomic level makes it possible to obtain objects such as nanotubes and fullerenes of two types: organic (carbon and polymer) and inorganic. [1, 2]

Carbon nanotubes are a unique and promising material. Various products can be made from them. They are superior to traditional materials due to their developed surface and structural stability.

Carbon nanotubes are used in many fields. But they have not yet found wide application in ecology. And ecology plays one of the important roles in the modern world. The problem of air pollution in large cities and industrial centers is especially acute. The main source of pollution is road transport.

All over the world, they are trying to develop or find highly effective adsorbents that allow solving problems in the field of ecology (control of pollutants and methods of purifying water and air media).

Environmental problems can be combined in one direction based on the use of nanostructures - nanotubes. The use and use of carbon nanotubes will solve many environmental problems.

Nanotubes are peculiar cylindrical molecules with a diameter of about half a nanometer and a length of up to several micrometers. Nanotubes exhibit a whole spectrum of the most unexpected electrical, magnetic, and optical properties. Nanotubes can be conductors, semi-metals, and semiconductors. Superconductivity is also observed in them. Despite their apparent fragility, nanotubes turned out to be an extremely strong material, both in tension and bending. Moreover, under the action of mechanical stresses exceeding critical ones, nanotubes do not break, but rearrange their structure (Figure 1). [2, 4]

![Figure 1. Nanotube structure](image)

Inorganic nanotubes occur naturally in the form of minerals. One of these minerals is asbestos. There are two main types of asbestos - chrysotile asbestos and amphibole asbestos (Figure 2). [3]
Chrysotile asbestos is a fibrous mineral of the serpentine group, hydrous magnesium silicate \( \text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4 \). The chemical composition can vary depending on a particular deposit. Al, Fe, Ca, Ni, Mn, K, Na may be present in it as impurities. Chrysotile asbestos is the main type of asbestos used in industry today.

Chrysotile asbestos has a very interesting non-standard crystal structure (Figure 3).

It consists of structural layers, which are bounded on the inside by a silicon-oxygen network, and on the outside - by a network corresponding to magnesium hydroxide. Since the size of the inner mesh is smaller than the outer one, the layers of chrysotile asbestos tend to roll into cylinders (tubes). [5]

In addition to fire resistance, resistance to acids and alkalis and other properties, the industrial value of asbestos is determined by the length of the fiber and its strength. So, according to the length of the fiber, chrysotile-asbestos is subdivided into 8 grades in Russia (from 0 to 7). For grade zero, the fiber length exceeds 13 mm, and for grade 7 - less than 1 mm. [3]

Chrysotile asbestos is used for the production of fire-resistant suits (for firemen), pipes and slates, and all kinds of cardboard and paper products. Iron-free chrysotile asbestos is an electrical insulator and is used in industry. The best long-fiber grades of chrysotile asbestos are used in the textile industry. The highest quality fiber is used to make filters.

None of the known asbestos substitute materials has the entire range of useful properties that chrysotile asbestos possesses [6, 7]:

- tensile strength over 3000 MPa (surpasses steel);
- density from 2.4 to 2.6 g/cm³;

Figure 2. Amphibole asbestos

Figure 3. Chrysotile asbestos
Chrysotile asbestos is a naturally occurring nanosized tube with a spread in diameter, closely packed in a mineral and collected in bundles. It should be noted that chrysotile asbestos is very similar in structure and properties to a carbon nanotube [9 - 11], and has many useful properties.

The main differences of chrysotile in comparison with carbon nanotubes [8, 12]:
- great rigidity;
- are initially multi-layered;
- tubes are formed open without fullerene hemispheres;
- the curvature (hence, the diameter of the nanotubes) is determined exclusively by the internal crystal structure;
- cheaper material.

3. Conclusion
Russia tops the world list of reserves and mining of natural and unique material chrysotile. Currently, in Russia and around the world, there is an acute problem of ecology, especially in motor transport. Scientists are trying to develop and find highly effective adsorbents that can solve problems in the field of ecology (control of pollutants and methods for purifying water and air media). The production and application of a new nanomaterial (chrysotile asbestos) can radically change the ecological situation.

References
[1] Eletskii A V 2002 Carbon nanotubes and their emission properties Advances of Physical Sciences (Moscow: UFN) p 401
[2] Eletskii A. V. 1997 Carbon nanotubes Advances of Physical Sciences (Moscow: UFN) p 954
[3] Lozovik Yu E and Popov A M 1997 Formation and growth of carbon nanostructures Advances of Physical Sciences (Moscow: UFN) p 263
[4] SRM 2483 Single-Wall Carbon Nanotubes 2013 (U.S. National Institute of Standards and Technology)
[5] ISO/TR 10929:2012 Nanotechnologies – Characterization of multiwall carbon nanotube (MWCNT) samples International Organization for Standardization
[6] Stando G, Lukawski D, Lisiecki F and Janas D 2019 Intrinsic hydrophilic character of carbon nanotube networks Applied Surface Science (Amsterdam: Elsevier) p 463
[7] Karousis N, Tagmatarchis N and Tasis D 2010 Current Progress on the Chemical Modification of Carbon Nanotubes Chemical Reviews (Washington: American Chemical Society) p 5674
[8] WO16072959 2018 Method for Carbon Materials Surface Modification by the Fluorocarbons and Derivatives Patentscope wipo.int.
[9] Haddon R, Zanello L, Zhao B and Hu H 2006 Bone Cell Proliferation on Carbon Nanotubes Nano Letters (Washington: American Chemical Society) p 567
[10] Noyce S, Doherty J, Cheng Z, Han H, Bowen S and Franklin A 2019 Electronic Stability of Carbon Nanotube Transistors Under Long-Term Bias Stress Nano Letters (Washington: American Chemical Society) p 1466
[11] Chin Wei T, Kok Hong T, Yit Thai O, Abdul Rahman M, Sharif Hussein Sharif Z and Soon Huat T 2012 Energy and environmental applications of carbon nanotubes Environmental Chemistry Letters (Switzerland: Springer Nature) p 1760
[12] Elishakoff I, Dujat K, Muscelino G, Bucas S, Natsuki T, Ming Wang C, Pentaras D, Versaci C, Storch J, Challamel N, Zhang Y and Ghyselinck G 2012 Carbon Nanotubes and Nanosensors: Vibration, Buckling and Ballistic Impact (USA: WILEY) p 448