МОСКОВСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ
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SUMMARY REPORT

on the research work

"STUDY USING MOLECULAR SPECTROSCOPY METHODS OF 40% WATER-ETHANOL SYSTEMS AFTER CAVITATION TREATMENT

(Raman scattering spectroscopy, absorption and luminescence spectroscopy)"

The main results and conclusions of the entire report:

(direct quotation of the report summary from pages 23-24)

“As a result of the conducted spectroscopic research performed on the provided samples and prepared water-ethanol solutions with different alcohol content and varying types of cavitation treatment, the following conclusions were made:

1). The cavitation treatment leads to a reduction of impurities in pure ethanol as well as in alcoholic solution prepared from treated ethanol, which absorb light in the UV range and emit fluorescence in the UV and visible range. The doubled hydrodynamic cavitation treatment in the high pressure cavitator (H.P.) also removes impurities with a maximum of fluorescence at 400-450 nm.

The mechanism of action of cavitation treatment on the organic impurities in aqueous alcoholic systems may involve breaking of the double bonds in the carbon chain and shortening of the conjugated electronic system. This therefore leads to a decrease in the absorption of light in the optical UV range and a decrease in fluorescence emission (both in the UV and in the visible range) excited by wavelengths in the UV range.

2). The wavelength of maximum and the band shape of the stretching band in the Raman scattering spectrum for the 40% (v/v) alcohol solution treated by cavitation differ from that for the unprocessed alcohol solution of the same ethanol concentration: the OH-stretching band shifts towards the high-frequency wavenumber region, and the parameter c_{21} (the intensities ratio at high-frequency to low-frequency region). This means that after cavitation processing in the 40% alcohol solution, the number of OH-groups with weak hydrogen bonds is greater than in the untreated sample. The ratio of the integral intensities of the stretching bands of the CH- and OH-groups in water-ethanol solutions is significantly greater for processed ABI solutions that have been processed with cavitator after preparation than for the solutions prepared at MSU from previously treated water and ethanol.

In aqueous solutions of ethanol, the existence of various molecular structures like water clusters, clusters of ethanol molecules or heterogeneous water-ethanol associates (hydrated ethanol) is possible. At high alcohol content (~40 vol %) ethanol clusters appear. These ethanol clusters undoubtedly stimulate the palate differently from either water clusters or the clathrate-like water-ethanol structures. Even in the absence of “taste” in the traditional sense, vodka drinkers could express preference for a particular structure. It is possible that trace impurity compounds influence Hydrogen-bonding and thus alter the component distribution.

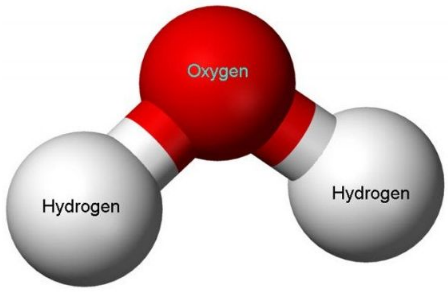
3) Cavitation ethanol treatment reduces significantly, by 1.5-2 times, the content of impurities such as mono-and polyaromatic compounds (derivatives of benzene, phenol, tyrosine, tryptophan, benzaldehyde, and other organic compounds). A significant reduction of impurities in alcohol and alcohol solutions after cavitation treatment can improve the organoleptic characteristics of alcohol-based beverages used in the food industry.”

APPENDIX TO THE REPORT:

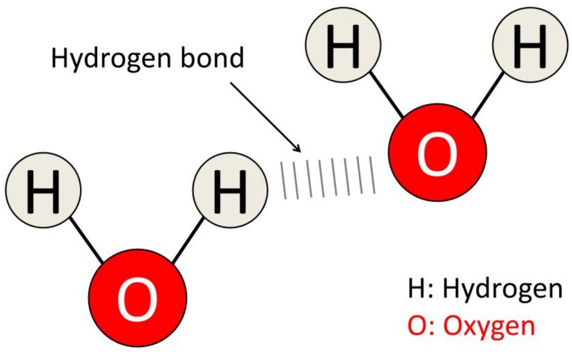
How the Molecular Restructuring Works and Why it Matters to Taste

Structuring of alcoholic beverages

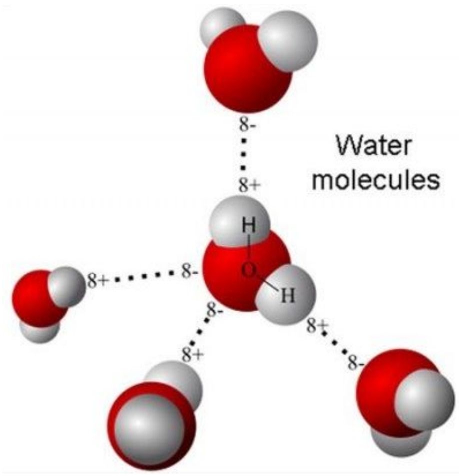
A water molecule consists of an oxygen atom and two hydrogen atoms.



The water molecule has two free (non-compensated) positive charges of hydrogen atoms and two negative charges on the oxygen atom. Since two hydrogen atoms are located asymmetrically relative to the oxygen atom, the so-called hydrogen bonds are formed between water molecules.

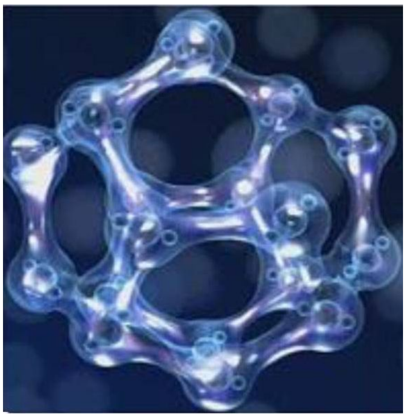


Hydrogen bonds can combine several water molecules simultaneously.



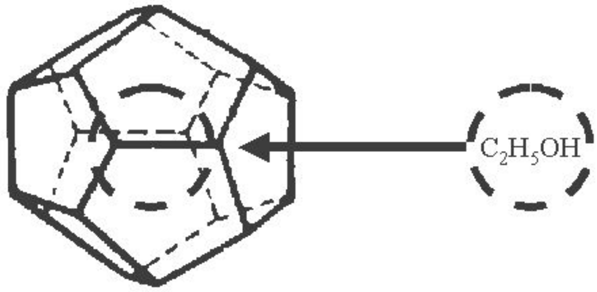
Water molecules can quickly form large regular formations, which are called clusters.

Clusters of water molecules can form cluster associations.



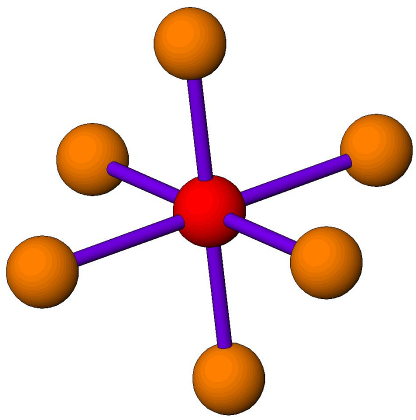
Clusters are formed, continuously rebuilt, disappear and appear again for a very short time interval.

When alcohol (ethanol) is dissolved in water, its molecules are distributed among water molecules, including water clusters, forming clusters of water molecules and ethanol.



Clusters of water molecules and ethanol can have different ratios in the number of molecules: from one water molecule per ethanol molecule to 12 or more water molecules per ethanol molecule.

An example of a cluster- like structure of six water molecules and one ethanol molecule is given below.



The stability of cluster-like structures of ethanol water solutions depends on the strength of hydrogen bonds between molecules.

For an equal ratio of water molecules and alcohol molecules, a cluster structure, which is similar to the structure of polymers, is typical.

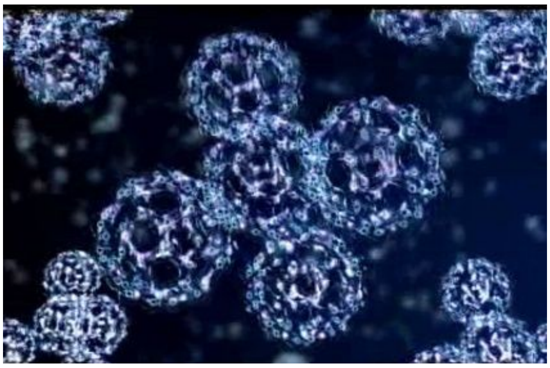
Aqueous solutions of ethanol are used in the food industry for the preparation of various alcoholic beverages. Pure ethanol solutions with an alcohol concentration of 35% to 42% are used to produce various types of vodka.

It is possible to affect structuring - the formation of cluster-like structures in water and aqueous solutions of alcohol –owing to various physical factors: temperature, pressure, acoustic oscillations and other effects.

Cavitation is used to change the structure of water. Cavitation is often referred to as the process of cold boiling of water, because during cavitation, vapor bubbles occur and collapse. During pulsations and collapse of cavitation bubbles, the pressure and temperature in a compressed bubble can reach values of the order of 10,000 atm and up to 10,000 ° C. The energy released during the bubble collapse is sufficient for the excitation, ionization and separation of water and ethanol molecules inside the cavitation cavity.

When a cavitation bubble collapses, H, OH radicals, low energy ions and electrons,the products of their interaction and partial re-combinations, as well as metastable excited water molecules transfer into the solution during dissociation of the water molecule.

These phenomena contribute to a local increase in the energy of the hydrogen bond in the interaction of molecules and an increase in the number of cluster-like structures in an aqueous solution of alcohol.



Professor Hojo, the author of the book "**Alcoholic Beverage Consumption and Health**" (2009), has long been exploring hydrogen bonds in alcoholic beverages. He proved that the strength of hydrogen bonds depends not only on the concentration of ethanol, but also on the presence of impurities. He concluded that it is the strength of the hydrogen bond that affects the taste and the quality of alcoholic beverages. The stronger the hydrogen bonds are and the larger the cluster structures of the water and ethanol molecules are, the better the drink is.

https://www.researchgate.net/profile/Masashi_Hojo/publication/286608894_Interaction_between_water_and_ethanol_via_hydrogen_bonding_in_alcoholic_beverages/links/59d23ba3aca2721f4369a126/Interaction-between-water-and-ethanol-via-hydrogen-bonding-in-alcoholic-beverages.pdf