ENVIRONMENTAL SAFETY OF MINERAL SUPPLEMENTS IN THE ANAEROBIC FERMENTATION OF AGRICULTURAL WASTE

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The energy consumption needs of society are increasingly dependent on natural gas in terms of ease of use and environmental friendliness. However, the significant development of biotechnology has made it possible to obtain a better analog – biogas and biomethane. Besides, the direction of the anaerobic production of hydrogen is being actively developed. It is obtained in the process of anaerobic fermentation of biological raw materials (manure, waste from agricultural production and processing of agricultural products, biomass, etc.) on biofuel plants. It is noted that agricultural waste is easily fermented and is a significant supply of raw materials for a variety of organic products. Besides, anaerobic processing of agricultural waste is one of the promising areas for improving the environmental safety of agriculture.

The growth and activity of methane bacteria require the presence of organic and mineral nutrients in the raw material. In addition to carbon and hydrogen, the creation of biofertilizers requires a sufficient amount of nitrogen, sulfur, phosphorus, potassium, calcium, magnesium, and many trace elements - iron, manganese, molybdenum, zinc, and others [1].The reproductive activity of methane-forming bacteria is largely determined by the ratio of carbon and nitrogen in the raw material. The criterion for the optimal ratio of C:N is the yield of biogas. If the ratio of C:N in the manure is excessive, then the lack of nitrogen limits the process of methane fermentation, if the ratio is very small, a large amount of ammonia is formed in the methane tank and it becomes toxic to bacteria. A C/N ratio of 10:1 to 30:1 is considered favorable for the reproduction of methane-forming bacteria [2].This parameter is adjusted by adding to the utilized biomass waste with high nitrogen content, such as chicken manure or pig manure. Optimization of the environment with a high content of ammonia is achieved by adding crushed biomass with high carbon content, such as straw [3].

Research done by Schnurer and Jarvis (2010) investigated the process of substrate destruction by anaerobes using both intracellular and extracellular enzymes. The chemical composition of organic waste is complicated; it contains a large variety of particulate, colloidal, and soluble substrates. Each enzyme can degrade only a few specific substrates. Therefore, diverse enzymes are required to ensure complete degradation of substrates that are present in the feed organic waste [4].

Enzyme additives have been applied successfully in lactic acid and alcohol fermentation using food waste (FW). Protease and amylase additives were also used to enhance the solubilization of waste activated sludge by 39.7% and 54.2%, respectively. It can be concluded that enzyme additives are more effective for FW than for waste activated sludge because it is more difficult to break bacterial cell walls [5].Substrates can contained toxins (e.g., butyric acid, free ammonia, hydrogen sulfide), which can accumulate during the anaerobic digestion (AD) process and can result in a low biogas production or system shut-down. Therefore, supplemental additives for promoting biogas production have attracted more attention. Additives are added to improve the AD process performance by supplying deficient nutrients or by reducing impacts from toxins in the feed. Mineral additives are also sub-divided into macronutrients (nitrogen, phosphorous etc.) and micronutrients (Fe, Zn etc.)[6].

In the study of Xiaofei Lu et al. (2018) showed that the method of adding iron oxide and zeolite is an advanced and feasible approach for achieving successful biogas production in AD through animal waste treatment (fig.1) [7].

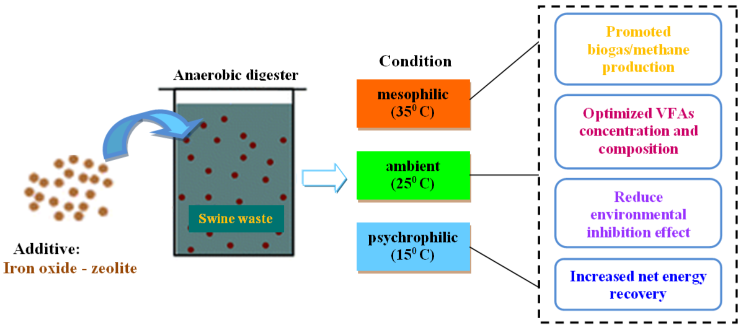

Figure 1 – Effects of an iron oxide–zeolite additive on process performance of anaerobic digestion [7]

Combinations of trace elements can exhibit significant synergistic effects. Increased concentrations of Ni and Co can accelerate initial exponential rates, increase the total volume of methane produced, and increase cell densities of methanogens. Other metals, such as Se, Mo, and W, which may increase AD performance are required 10-times lower concentration than Fe, Ni, and Co [8].

Often, these elements are fed in excess for other purposes. For example, H_2S, which is produced as a by-product during the AD process, can inhibit the growth of methanogens. One approach to control H_2S toxicity is to add iron, as it reacts with H_2S to form a salt precipitate (i.e., FeS). Similarly, magnesium can reduce the accumulation of ammonia in the mixed liquor through magnesium ammonium-phosphate (MAP) crystallization.

Household FW subject to anaerobic disposal contains a large amount of lignin, cellulose, and lipid, which could be affected for the microbial activity of methanogens and the disintegration of organic compounds. Therefore, anaerobic digestion of FW is required to enforce the methanogen activity and primary degradation steps for biogas production by using a biological enzyme such as cellulase, lipase, and protease [6].

Therefore, the combined additive can be used for promoting biogas production in practice. Many studies [6,9,10] have experimentally shown that anaerobic production of biogas can be stimulated by the addition of various supplements to substrates that can reduce the internal toxicity of substrates. Therefore, further research should be conducted to improve these methods, developing combinations of additives that will help to destroy the inhibitory effect of the substrate.

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АНАЛІЗ УМОВ ЗАСТОСУВАННЯ ГУМОВОЇ КРИХТИ З ЗНОШЕНИХ ШИН ДЛЯ ВИРОБНИЦТВА ДОРОЖНІХ ПОКРИТТІВ НА АВТОМОБІЛЬНИХ ДОРОГАХ

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Ставлення в світі до бітумних композицій з використанням гумової крихти неоднозначно. До незаперечних переваг застосування гумових асфальтобетонів в шарах покриттів автомобільних доріг належать:

– збільшення міжремонтних термінів і підвищення опору впливу t°;

– підвищення стійкості до утворення тріщин, що пов'язано з високою еластичністю і теплостійкість гумовобітумного в'яжучого. При використанні гумової крихти від 0 до 1,0 мм тріщиностійкість знижується на 30 %. Зі зменшенням розміру частинок тріщиностійкість збільшується. Особливо ефективним є застосування часток крихти від 0,14 мм і менше. Частинки менше 0,08 за час перемішування розпадаються і покращують його властивості;

– поліпшення опору окислювальному старінню, що пов'язано з наявністю більш товстих плівок в'яжучого і присутністю антиоксидантів в шинній гумі;

– підвищення опору утворення колії, що обумовлено високою в'язкістю гумовобітумного в'яжучого при підвищених температурах;

– поліпшення фрикційних властивостей покриттів (підвищується зчеплення колеса з покриттям). Застосування гумової крихти в асфальтобетоні в два рази підвищує коефіцієнт зчеплення на мокрому покритті;

– зниження рівня шуму в середньому на 3 – 5 дБ;

– підвищення безпеки в зв'язку з найкращим цвітовим контрастом покриття з розміткою, оскільки сажа діє як пігмент, який зберігає колір чорним;

– утилізуються великотоннажні відходи - зношені шини.