Trend Analysis of Domestic and Foreign Liquid Scintillation Counter (LSC) Cocktail Waste Treatment Technology

S.Y. Jeong [a], S.J. Lim [b], W.J. Yoo [a], S.R. Kim [a], J.M. Oh [a], B.R. Lee [a], J.U. Kim [a], H.J. Kim [a], H.Y. Shin [a], K.T. Park [a *]
[a] *Orbitech Co.,Ltd., 1130, Beoman-ro, Geumcheon-gu, Seoul*
[b] *Korea Atomic Energy Research Institute, 111, Daedeok-daero 989beon-gil, Yuseong-gu, Daejeon*
[*] *Corresponding author: paradoxno1@orbitech.co.kr*

1. Introduction

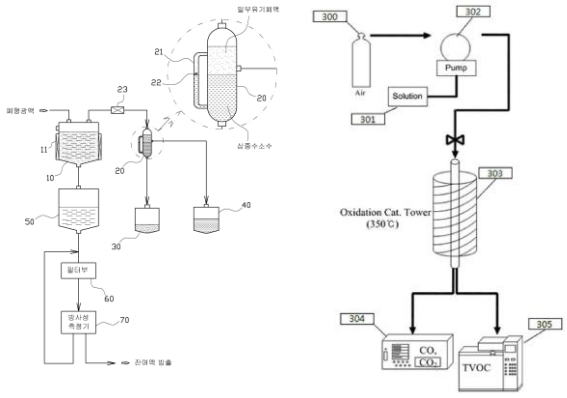
Liquid Scintillation Counter (LSC) is widely used as an instrument for measuring radioactivity of radioactive isotopes (^{3}H, ^{14}C, ^{32}P, etc.) that emit low-energy beta and alpha rays in a sample. It is an indirect method of measurement by mixing radionuclides that emit low-energy beta and alpha rays with a liquid called a scintillation cocktail. Since the radiation emitted by radionuclides is low-energy and has a short range, the use of a scintillation cocktail is essential to measure it. However, the scintillation cocktail used in the measurement is radioactive and has high explosiveness, inflammability and volatility, so it is stored for a long time in the laboratory without proper treatment technology. Korea Hydro & Nuclear Power Co., Ltd. (KHNP), a domestic nuclear power plant (NPP) operator, is also storing all of them on site due to lack of proper scintillation cocktail waste treatment technology with proven stability. As the technology that can safely handle the scintillation cocktail waste is continuously needed, this paper investigated the trend of scintillation cocktail waste treatment technology at domestic and foreign.

2. Methods and Results

In this section, we investigated and analyzed domestic and foreign scintillation cocktail waste treatment technology trends.

2.1 Domestic Case

The most common and effective treatment method is incineration. In addition, the method of immobilizing by embedding in cement or geopolymer matrix is also widely used. In Korea, several related companies hold patents on scintillation cocktail waste treatment technology. Elim Global Co., Ltd. holds a series of treatment technology that classify scintillation cocktail waste according to its moisture content and incinerate it in an incinerator when the moisture content is less than 20% [1]. However, this method has disadvantages in that it is expensive, the process is complicated and it takes a long time to treatment. Korea Nuclear Power Engineering Co., Ltd. Has the technology to heat and treat the scintillation cocktail waste without incineration by taking advantage of the fact that the boiling point and specific gravity of the main components (organic solvent, tritium water, surfactant, fluorescent agent, etc.) are different [2]. Korea Atomic Energy Research Institute has the technology to decompose radioactive materials in the scintillation cocktail waste with active substances generated by irradiating radiation [3]. This technology also has the advantage of being able to treat not only acidic but also alkaline and neutral. Hana Inspection Technology Co., Ltd., has the technology to completely oxidize ^{14}C and ^{3}H contained in scintillation cocktail waste into CO_2 and H_2O using a catalyst at low temperature (300-350℃) [4]. Fig. 1 is a representative diagram of the technology possessed by Korea Nuclear Engineering (a) and by Hana Inspection Technology (b).



(a) Korea Nuclear Power Engineering [2]

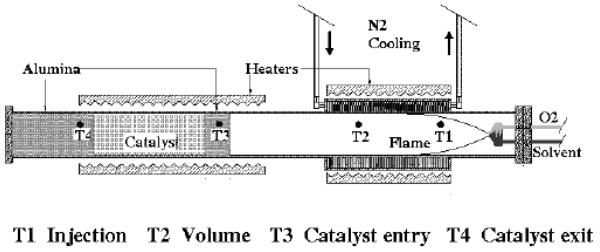
(b) Hana Inspection Technology [4]

Fig. 1. Representation of scintillation cocktail waste treatment technology possessed by each company.

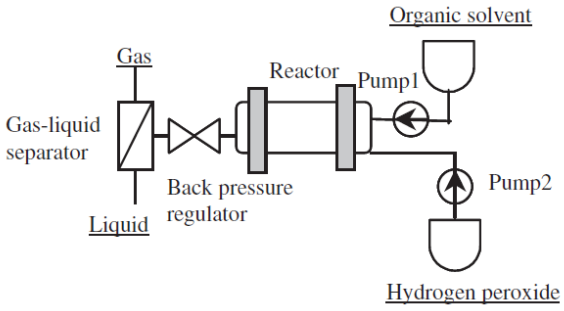
2.2 Foreign Case

Attila Baranyi et al. conducted experiments to find the optimal mixing ratio of reagents for solidifying and fixing scintillation cocktail of unknown composition [5]. As a result, they used CEM I 42.5 N type cement, Metaver N type metakaolin and sodium hydroxide to find an appropriate mix design that solidifies all available scintillation cocktail up to 5% [5]. Magdalena Dianu et al. solidified using Portland cement and aluminum stearate matrix in a standard container to treat Ultima Gold scintillation liquid waste, and confirmed that this waste satisfies the national disposal standards [6]. Maha A. Youssef et al. investigated the adsorptive performance clay adsorbents to successfully remove $^{90}Sr/^{90}Y$ from KU-2 resin, bentonite, charcoal (M&S)

and liquid scintillation cocktail waste [7]. As a result, the efficiency of the adsorbent appeared in the order of resin > bentonite > clay, and charcoal did not adsorb well [7]. Johan Braet et al. performed a two-stage combustion experiment to thermally and catalytically oxidize tritiated organic for the treatment of liquid waste and release tritium free off gas [8]. And application of this technology to the treatment of tritiated organic liquid at Joint European Torus (JET) produced low-TOC water, but limited tritium emissions through the vents were confirmed [8]. Yoshie AKAI et al. developed a technology to quickly and completely decompose scintillation cocktail and various organic solvents such as TBP, turbine oil and silicon oil into H_2O and CO_2 using supercritical water oxidation [9]. And they confirmed that the decomposition yield of scintillation cocktail increased with reaction time, temperature and pressure [9]. Fig. 2 is a schematic diagram of the technology developed by Johan Braet et al. (a) and by Yoshie AKAI et al. (b)



(a) Johan Braet et al. [8]



(b) Yoshie AKAI et al. [9]

Fig. 2. Schematic diagram of scintillation cocktail waste treatment technology developed by each researcher.

3. Conclusions

In this paper, we investigated the trend of scintillation cocktail waste treatment technology at domestic and foreign. In domestic, many related patents have been registered, and in foreign, many related papers have been published. However, the number of technologies announced in the last three years was rather small, and most of the technologies announced in the past. Recently, as the need for safe and effective treatment and disposal technology for scintillation cocktail waste has emerged, active research and development is required.

REFERENCES

[1] Elim Global Co., Ltd., Radioactive organic fluorescent waste treatment method and incineration treatment device, 10-2113585, 2020.
[2] Korea Nuclear Power Engineering Co., Ltd., Radioactive fluorescent solution waste treatment method, 10-2014849, 2019.
[3] Korea Atomic Energy Research Institute, Liquid Scintillation Counter liquid waste treatment method, 10-2019-0173693, 2019.
[4] Hana Inspection Technology Co., Ltd., Method for treating organic waste containing radioactive materials including fluorescent solution waste, 10-0932670, 2009.
[5] A. Baranyi, K. Kopecsko, Preliminarily Experiments of Liquid Scintillation Cocktail Waste Solidification, Periodica Polytechnica Civil Engineering, Vol.66, p.1234-1240, 2022.
[6] M. Dianu, C. Podina, The Safety of environment in final disposal of Ultima Gold scintillation liquid cocktail used for determination of radioactive content in various samples at Cernavoda Nuclear Power Plant, Revue Roumaine de Chimie, Vol.52, p.509-519, 2007.
[7] M. A. Youssef, H. E. Rizk, M. F. Attallah, Purification of liquid scintillation waste from binding radionuclides using different adsorbents, Radiochim, Vol.108, p.879-887, 2010.
[8] J. Braet, A. Bruggeman, Oxidation of Tritiated Organic Liquid Waste, Fusion Science and Technology, Vol. 48, p.188-193, 2005.
[9] Y. AKAI, H. OOMURA, K. YAMADA, T. TAKADA, Liquid Scintillation Counter Cocktail Decomposition in Supercritical Water, Nuclear Science and Technology, Vol. 44, p.1089-1094, 2007.

ACKNOWLEDGEMENT

This research was supported by SME technology innovation development project (market expansion type) through the Korea Technology and Information Promotion Agency for SMEs (TIPA) funded by the Ministry of SMEs and Startups (No. S3324880).