CHEMICAL AND PHYSICAL PROPERTIES

SECTION A11
RADIOACTIVITY

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CABOT

VERSION 2 – 09/13

A11.1 Introduction

The first question many people ask when they first hear the word cesium formate is: "Isn't that very radioactive?" The fact is that radioactive cesium isotopes, which originate exclusively from nuclear reactions, are not used by Cabot for production of cesium formate brine. Consequently, cesium formate brine is not radioactive.

On the other hand, potassium formate, like all other natural substances containing potassium, has a certain level of the naturally occurring radioactive isotope, ^{40}K. Consequently, as stock 75% w/w potassium formate brines contain a large amount of potassium, there is a sufficient concentration of ^{40}K present to be detectable by sensitive radiation sensors.

A11.2 Cesium and potassium radioactivity

Cesium is a soft gold-colored metal with a melting point of 28.5°C / 83.3°F. It has a relative atomic mass of 132.9 and its atomic number is 55. There are 35 known isotopes of the element cesium: ^{114}Cs to ^{148}Cs [1]. Cesium has only one naturally occurring stable isotope, ^{133}Cs. This non-radioactive isotope is present in various ores and at lower concentrations in soil and sea (cesium is the 29th most abundant element in seawater with a concentration level of 370 kg per cubic kilometer of water). All other *Cs* isotopes found in the environment are man-made products of atomic bomb explosions or nuclear reactions. Only three of these have half-lives long enough to warrant concern: ^{134}Cs, ^{135}Cs, and ^{137}Cs. The ^{137}Cs isotope with a half-life of 30 years is the isotope of most concern. The radioactive isotopes are all products of nuclear fission of ^{235}U. The presence of these radioactive isotopes in the soil around the world originates from fallout from past atmospheric nuclear weapons tests.

All cesium-based salts and brines manufactured by Cabot originate from naturally occurring pollucite ore, which exclusively contains the non-radioactive ^{133}Cs. The radiation levels of the stable ^{133}Cs isotope are lower than background noise, and also lower than radiation levels of natural potassium compounds.

In contrast to cesium, potassium has a naturally-occurring radioactive isotope, ^{40}K. It was formed together with other elements during the creation of the Earth. Due to its long half-life of 1.28 billion years, it is still present on earth. ^{40}K is the only radioactive isotope of potassium and is present in natural potassium at a concentration of 0.0119%. The other isotopes making up potassium as we know it are ^{39}K and ^{41}K with frequencies of 93% and 6.9% respectively. One gram of natural potassium contains 31.6 Bq ^{40}K [1]. Hence, the activity of ^{40}K can be used to quantitatively determine total potassium. Potassium, including ^{40}K, is present in most terrestrial and biological substances. The body of a 70 kg person contains about 140 g of potassium and thus an activity level of 4,000 Bq ^{40}K. Due to its presence in almost all food, ^{40}K accounts for the greatest proportion of the naturally occurring radiation load through ingestion among people.

A11.3 Radioactivity levels in cesium and potassium formate

In order to assure all users of oilfield grade cesium and potassium formate brines that these fluids are free of any radioactive isotopes above naturally occurring levels, Cabot has contracted specialist laboratories to run radioactivity detection tests on standard samples of cesium and potassium formate used by the oil industry.

A11.3.1 Measurements by AECL, Whiteshell Laboratories

A cesium formate sample from Cabot has been analyzed by AECL, Whiteshell Laboratories to confirm absence of radioactive isotopes [2]. The sample was tested by gamma-spectrometry and total alpha / beta / gamma analysis (liquid scintillation counting).

The test results (see Figure 1) confirm that cesium formate supplied by Cabot contains levels of radioactivity that are actually lower than natural background noise.

A11.3.2 Measurements by Weston Solutions

In May 2007, Weston Solutions visited a storage facility for formate brines in Houston. Radioactivity was measured with field detectors on a range of containers containing potassium formate and cesium formate brine. As typical portal radiation detectors, which are commonly employed at entrances to commercial landfills and along highways and international borders, are sensitive to gamma radiation, these field measurements focused on assessing this radiation type. Samples were collected from the potassium formate containers that exhibited the highest radiation levels. Two cesium formate samples were also collected. The samples were analyzed by gamma spectroscopy. The results are shown in Table 1 along with the field measurements.

Table 1 Results of field measurements and gamma spectroscopy for seven samples of potassium and cesium formate from Cabot's storage facility in Houston, Texas.

Sample	Field measurements		^{137}Cs [pCi/L]			^{40}K [pCi/L]		
	MicroR meter [uR/hr]	NaI detector [cpm]	Result	Uncertainty	MDA	Result	Uncertainty	MDA
KFo	30	67,500	U		92.31	454,900	32,590	724.5
KFo	30	72,820	U		92.06	466,800	33,440	730.4
KFo	32	71,567	U		61.13	527,800	36,910	410.9
KFo	28	60,818	8.205	33.86	57.78	471,000	31,760	437.8
KFo	30	66,569	10.53	36.52	60.45	483,800	32,100	438.5
CsFo	10	7,890	0.3232	7.436	12.38	2,277	260	104.7
CsFo	8	7,260	3.259	7.05	12.93	6,364	563	132.6

MicroR background = 6 uR/hr
NaI background = 11,682 cpm (counts per minute)
MDA = minimum detectable activity
U = undetected at the MDA

Results of the radiological analyses indicate that the major source of detectable radiation from these samples is natural *^{40}K*. *^{137}Cs* was not detected above the minimum detectable activity (MDA) level for the analytical method in three of the samples, and was detected in the other four samples at very low levels that were less than the MDA.

This study concludes that in cesium and potassium formate brines and their blends, the source of any detectable radioactivity would be natural *^{40}K*, which is found everywhere in nature.

References

[1] Seelmann-Eggebert W., Pfennig G., Münzel H., 1981: Nuklidkarte. Gesellschaft für Kernforschung mbH. Karlsruhe, 5. Aufl.

[2] AECL, Whiteshell Laboratories, Analytical Science Branch Analysis Report, January 2000.

[3] Weston Solutions: "Cabot Specialty Fluids, Inc. – Report of Radiological Measurements and Sample Analyses of Formate Products", 2007.

AECL, Whiteshell Laboratories
Pinawa, MB R0E 1L0

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ANALYTICAL SCIENCE BRANCH
ANALYSIS REPORT

Sample Description: Cesium formate liquid, in two 500 ml bottles, labelled # 174.
for analysis by gamma-spectrometry, and for total alpha/beta/gamma analysis by liquid scintillation counting.

Submitted By: BOB COPELAND
Branch: TANCO
W.O. #:
Stn. #:

RESULTS:

1) Gamma activity in Bq/kg

Nuclide	Gamma Activity	Error 2s	Detection limit
K-40	157.	6%	9.1
Bi-214	9.4	10%	1.2
Pb-214	6.1	16%	1.5

2) Total alpha/beta/gamma activity in Bq/kg

Activity	Error 2s	Detection limit
2050	5%	200

Remarks TEST METHOD: LP-RA-137 Ver 3.0

* Bi-214 and Pb-214 are decay products of Ra-226 which is part of the natural U-238 decay series.

Analysis Date(s): Jan 12, 2000
Report Date: Jan 13, 2000

Analyst: Ernie Bialas
Authorization: ____________________

Figure 1 Analytical science branch analysis report for cesium formate liquid.