Teflon Vials For Precise C-14 in Benzene Measurements by LSC Technique

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Abstract: We had developed and well tested vials in which Teflon and titanium where used as only materials. We avoid other material thinking about benzene sorption. We control counting efficiency avoiding presence of any "dead zone" inside. Vial flask and cap are spline coupled, both produced of Teflon. Other parts are of metal: stand, washer and valve. Vial volume ranges of: 0.8, 1.5, 2.5, 4.0 and 7.0 ml. Vials have extreme durability, low benzene leakage, high counting efficiency and low background. Benzene leakage is below 0.1% for one months of storage for series of vials.

Keywords: C-14, LSC, Teflon vial, titanium, extreme durability, low benzene leakage

1. Introduction

Application field of low-level liquid scintillation (LS) spectrometer includes conventional carbon dating. ^{14}C counting efficiencies can exceed 80%, depending on LS spectrometer configuration used. Background is optimized when Teflon is used as material [1]. It was established, that presence of different materials in counting vials could interfere on stability of counting performances [2], when part of benzene staying in vial volume is not counted. Variety of available carbon dating samples allows producing wide ranged benzene sample of 50 mg to 6.0 g. The conventional LS based C-14 dating method generally recommends use of 2.4-6.0 g C in 3.0 or 7.0 ml counting vials [1]. The small benzene sample radiocarbon dating using LS is seeing when reduced background [1-4]. To cover mentioned wide benzene range and taking into account requirements of optimization - lowering background and minimizing of benzene sample dilution we developed vial line - vials of several volumes: 0.8 ml, 1.5 ml, 2.5 ml, 4.0 ml and 7.0 ml.

We illustrate here ideas how our new Teflon vials are build, we show their performances and we describe approach how to use them.

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2. Materials and Methods

We had developed LS vials using Teflon and titanium as materials. Thinking about possible sorption, we except using of other materials. To control counting efficiency we avoid presence of any "dead zone" inside. Both, flask and cap were produced of Teflon, when metal base and pin valve are produced of titanium. Each vial uses spline Teflon to Teflon coupling and metal washers. Metal base keep vials in vertical position. Fig. 1 shows technical scheme of vial. Produced vials line covers wide volume range, where each next have almost twice large volume: 0.8, 1.5, 2.5, 4.0 and 7.0 ml.

After filling with benzene sample, vial is covered with cap. Then walls of vial are lightly compressed to reduce air in vial, and after that, pine valve located in cap finally closes inner volume of vial. This, last one, keeps vial under minor vacuum and minimizes benzene leakage.
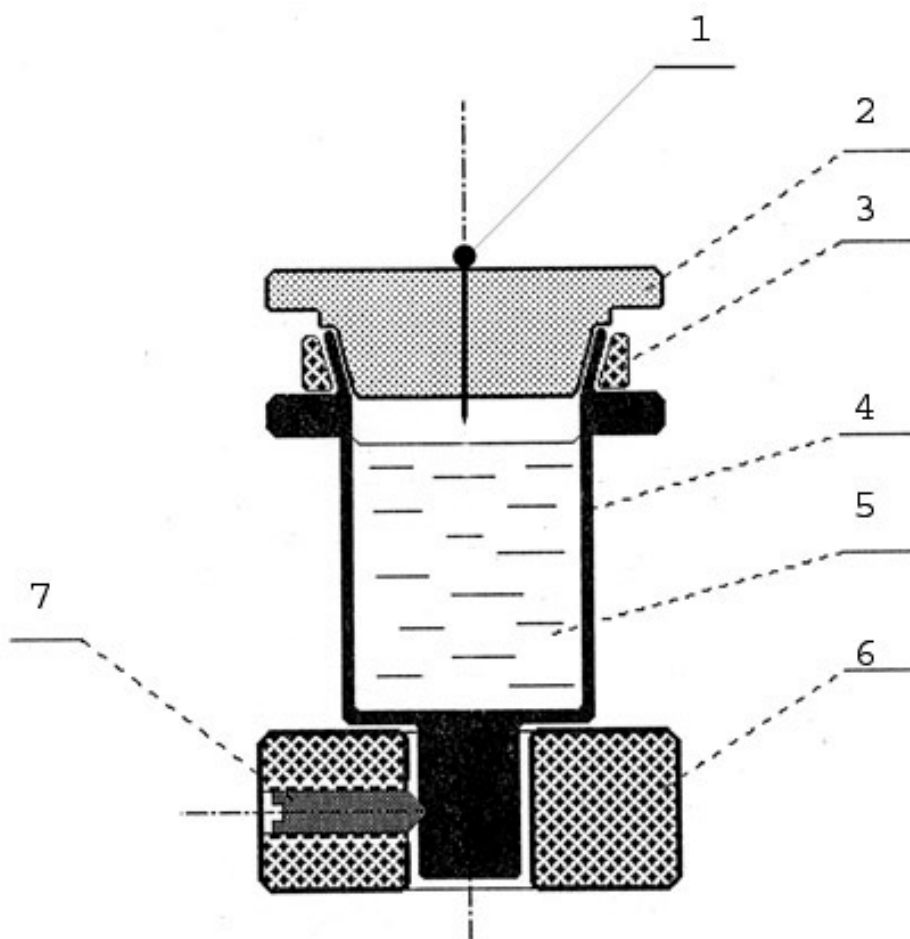
Fig. 1 Construction scheme of Teflon vial: 1 – pin valve, 2 – Teflon cap, 3- Titanium spring, 4 – Teflon flask, 5 – benzene sample, 6 - Titanium holder, 7 – screw.

Table 1 Counting Performances of Teflon Vials Using a LS spectrometer Quantulus 1220^{TM}

Vial	V, ml	Benzene, g	E, %	BG, CPM	FOM	FOM(V)
0.8ml	0.82	0.70	69,8	0.11	44320	24270
1.5ml	1.38	1.17	73,3	0.14	38360	58980
2.5ml	2.66	2.26	72,9	0.22	24150	137950
4.5ml	4.51	3.83	73,1	0.32	16720	275560
7.0ml	6.51	5.53	73,1	0.42	12720	436780
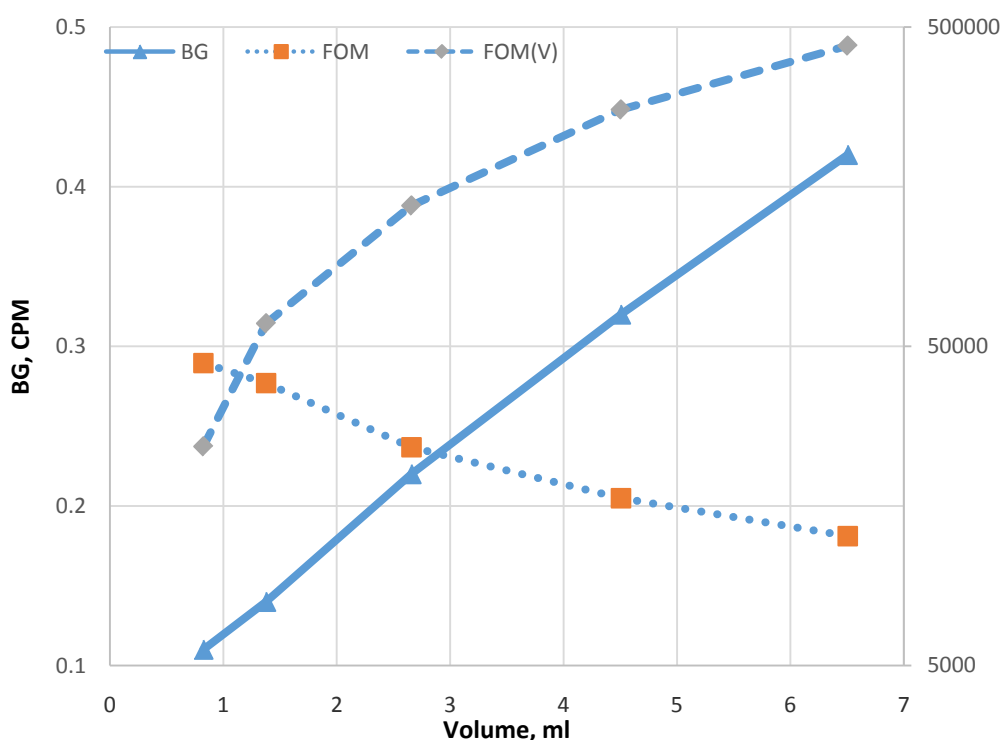
Fig. 2 Comparison of counting performances of Teflon Vials for benzene ^{14}C counting

3. Results and Discussion

We had estimated counting performances: efficiency, background, FOM=E^2/BG and FOM(V)=(V^2·E^2)/BG using of LS spectrometer Quantulus 1220^{TM}. Where, FOM illustrate optimization of measurement activity and FOM(V) – optimization of activity concentration measurement, see Table 1, Fig. 2. Background count rate is similar to one for other Teflon vial of the same volume if measured in similar counting condition. Counting efficiency, measured for some vials (2.5ml and 4.0ml) is higher because of better light collection achieved by

optimal ratio of height and diameter of flask. Benzene leakage estimated for series of vials is below 0.1% for one months of storage. Fig 3 shows Teflon vial line photo.

4. Conclusion

Novel Teflon vials show high and stable performances and long duration. Benzene percent leakage is below 0.1% at least for 4 weeks counting. Vials in set have different diameter to hight ratio, but looks alike, see Fig. 3.

Fig. 3 Photo of Teflon vial line

Acknowledgments

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