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Particle Size of Simulated SRS Sludge, Actual SRS Sludge, and Monosodium Titanate

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Summary

The authors reviewed and compiled typical data from prior measurements of the size of simulated sludge, actual sludge, and monosodium titanate (MST) particles. For the actual waste, the authors attempted to collect all available data from prior measurements. Since few prior measurements exist and since these analyses occurred using different analytical methods that span over two decades, the authors cannot verify the consistency of the methods used to make the measurements nor fully ensure the reliability of the information.

The review found the procured MST (from 55-gallon drums) to have a median particle size of 4 – 5 μ, a maximum particle size of 16 μ, and approximately 2 vol % of the particles smaller than 1 μ. The sludge samples – whether simulated or actual – had a median particle size of 2 – 16 μ, a maximum particle size of 31 - 248 μ, and 1 – 9 vol % of particles smaller than 1 μ.

Introduction

The Savannah River Site (SRS) is developing a new High Level Waste (HLW) treatment process, caustic side solvent extraction (CSSX). The first step of the process adds monosodium titanate (MST) to adsorb strontium and select actinides. Operations then remove the MST and entrained sludge by crossflow filtration, and the filtrate is treated by the solvent extraction process to remove cesium. The decontaminated waste is grouted, and the concentrated waste is vitrified.

To aid design of the crossflow filtration system, one needs to understand the size of the sludge and MST particles. The authors report previous sludge and MST particle size data in this report.

Results

Table 1, and Figures 1 and 2 show the particle size of six vendor qualification MST samples.[1,5] The samples are from drums of MST slurry that were manufactured for use at the In Tank Precipitation Facility in the mid-1990s. One sample came from Boulder Scientific and five samples came from Optima. The Bolder Scientific MST was used in the rotary microfilter testing.[8] The Optima MST was qualified for use at the Alpha Removal Process.[1] The Optima samples are from a single lot number.

The median MST particle size measured 4 – 5 μ. The maximum particle size measured 16 μ, and approximately 2 vol % of the particles proved smaller than 1 μ. The five Optima samples show very good agreement.

Current and past procurement specifications require that the vendor provide MST as a slurry with no more than 1 vol % of the particles smaller than 1 μ and no more than 1 vol % of the particles larger than 35 μ.[9] Both attrition and clumping can occur during storage. The clumping can become significant when storage occurs without temperature control. Personnel generally need to use aggressive methods to suspend the settled solids.

Table 2, and Figures 3 and 4 show the particle size of six sludge samples.[2,3,4] Two of the samples are simulated sludge, and four of the samples are actual sludge. The Tank 41H sample was entrained sludge in dissolved saltcake.[7] The other actual sludge samples were concentrated sludge. The median particle size is 2 – 16 μ. The maximum particle size ranges between 31 and 248 μ, and 1 – 9 vol % of the particles are smaller than 1 μ.

In reviewing the sludge samples, the reader is reminded that the samples (except for Tank 41H) do not represent entrained sludge solids such as expected in the feed to either the Salt Waste Processing Facility or the Alpha Removal Process. Rather, the samples more characteristically reflect the bulk properties of the entire sludge. Such solutions typically contain only trace amounts of solids and typical sampling only collects 60 - 100 mL aliquots at any time.

Notice that the sludge samples show a broader distribution of particle sizes than does MST. This wider variance in particle size and the lack of a means to control size of sludge particles imply that sludge will dominate the filtration performance for the process. This agrees with prior studies that show that addition of MST results in a slightly beneficial impact on filter flux for a Mott cross-flow filter using simulated waste.[6]

Note that Figure 3 indicates that simulated sludges have not bound the distribution of particle sizes previously measured for actual waste. Unfortunately, one can not a priori determine whether the broader diversity in particle size for the actual sludge will result in measurably worse performance for the cross-flow filters in the Salt Waste Processing Facility or in the Alpha Removal Process.

Data does exist, from routine characterization of tank samples, that demonstrates solid particles present in waste samples with size below 0.45 μ. Often, researchers use a second filter (as small as 0.02 μ) to remove these particles. However, the bulk of the activity in the filtrate that passes through the 0.45 μ filters remains soluble.

We also remind the reader that the nominal filter sizes cited during characterization tank samples do not directly equate to vendor quoted sizes for a sintered metal filter. The difference in designations proves more pronounced, for instance, for the Mott cross-flow filters studies within this program. That vendor defines the 0.5 μ as one that rejects 50 % of the particles greater than 0.5 μ, 90 % of the particles greater than 1 μ, 99 % of the particles greater than 1.7 μ, and 99.9 % of the particles greater than 2.2 μ.[10] Similarly, the efficiency of any filter varies with the slurry processed. Nominal sizes relate to a specific standard slurry for a given vendor. The performance in extreme environments – such as alkaline, HLW solutions – will differ due to both the influence of the solution media on the material (e.g., swelling or leaching) as well as due to variances in the particle morphology, shape, and, size distribution.

Table 1. MST Particle Size[1,5]

Size (μ)	BSC-265-107 (vol %)	Optima 00-QAB-417#1 (vol %)	Optima 00-QAB-417#2 (vol %)	Optima 00-QAB-417#3 (vol %)	Optima 00-QAB-417#4 (vol %)	Optima 00-QAB-417#5 (vol %)
704	0	0	0	0	0	0
497.8	0	0	0	0	0	0
352	0	0	0	0	0	0
248.9	0	0	0	0	0	0
176	0	0	0	0	0	0
124.5	0	0	0	0	0	0
88	0	0	0	0	0	0
62.23	0	0	0	0	0	0
44	0	0	0	0	0	0
31.11	0	0	0	0	0	0
22	0	0	0	0	0	0
15.56	1.3	0.24	0.24	0.24	0.24	0.25
11	11.98	6.18	6.17	6.28	6.27	6.33
7.778	27.06	21.05	21.04	21.19	21.01	21.29
5.5	28.09	32.03	32.06	32.07	31.92	32.3
3.889	11.08	16.48	16.43	16.53	16.6	16.28
2.75	8.09	9.38	9.34	9.28	9.44	9
1.945	6.24	7.39	7.42	7.29	7.35	7.32
1.375	4.47	5.25	5.28	5.16	5.2	5.22
0.972	1.69	2	2.02	1.96	1.97	2.01

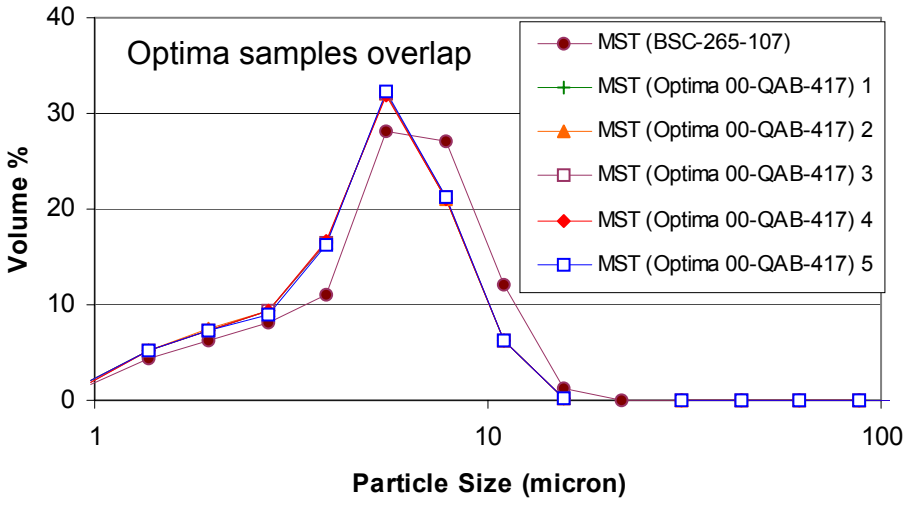

Figure 1. MST Particle Size

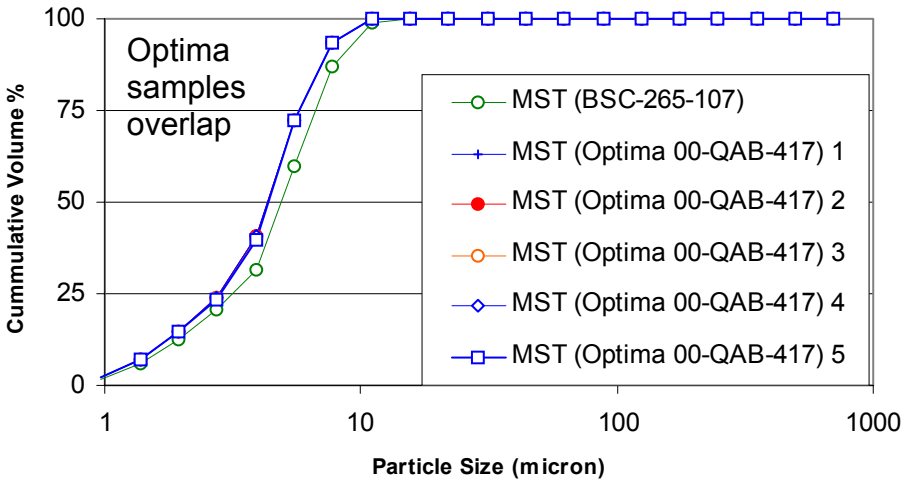

Figure 2. MST Cumulative Particle Size

Table 2. Sludge Particle Size[2,3,4,7]

Size (μ)	Tank 40 Simulated sludge (vol %)	Tank 8 Simulated sludge (vol %)	Tank 41H Sludge (vol %)	Size (μ)	Tank 5 Sludge (vol %)	Tank 13 Sludge (vol %)	Tank 15 Sludge (vol %)
704	0	0	0	57	4	4	6
497.8	0	0	0	45	5.5	5	5
352	0	0	0	36	9	4.5	5
248.9	0.01	0	3.14	28.5	4.5	4	5
176	0.13	0	3.65	23	8	5	5.5
124.5	0.18	0	5.86	18	8	5	4
88	0.82	0	6.61	14.2	5	5.5	4
62.23	1.53	0	7.23	11.5	6	5.5	4
44	1.7	0	7.47	9.1	4	5	3
31.11	2.17	0.01	7.61	7.1	4.5	5	3
22	3.76	0.65	7.58	5.7	4	6	3
15.56	4.83	3.27	8.97	4.5	4	6	3.5
11	5.61	8.41	9.73	3.55	3.5	6	4
7.778	6.79	15.37	8.54	2.85	4	7	6
5.5	6.76	18.47	8.80	2.3	4.5	5	9
3.889	4.06	11.67	6.05	1.8	6	6	10
2.75	15.62	14.03	4.54	1.4	4	5	8.5
1.945	19.55	12.81	2.42	1.1	4	4	7
1.375	17.99	10.49	1.51	0.9	2	2	5.5
0.972	9.49	4.82	0.29	0.71	1.3	1.5	6.5

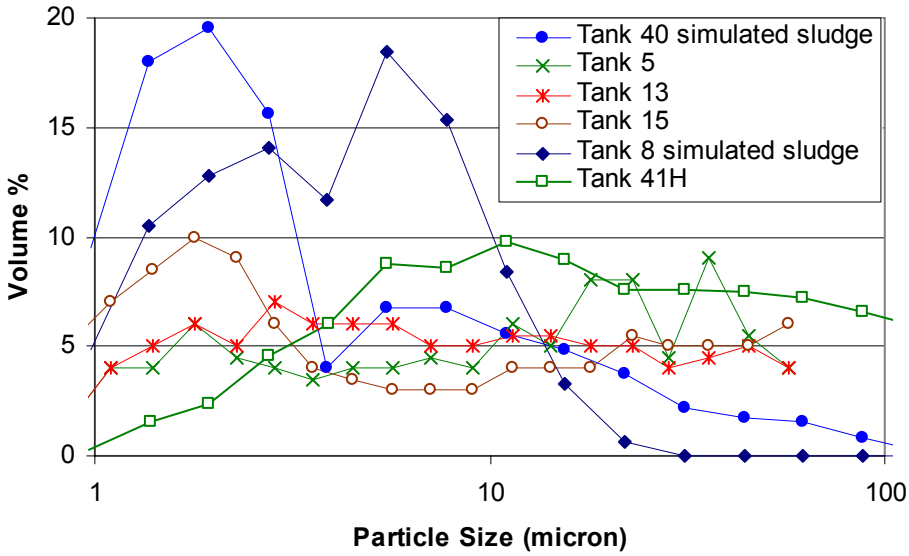

Figure 3. Sludge Particle Size

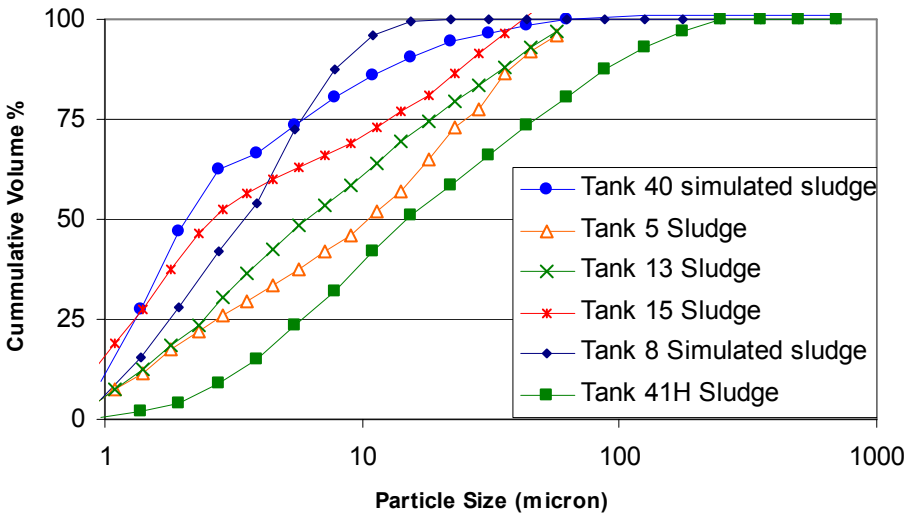

Figure 4. Sludge Cumulative Particle Size

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