How does Bharti FerroSorp® S compare with activated carbon with regard to the capability ofremoving impurities such as VOCs and siloxanes?

What are Siloxanes and VOCs?

Siloxanes are compounds which have a molecular structure based on a chain of alternate silicon and oxygen atoms, especially (as in silicone) with organic groups attached to the silicon atoms. Siloxanes need to be removed because fuels containing siloxanes essentially form sand when burned, ruining engines, expensive gas turbines and compressors.
Siloxanes are found in the form of one to six silicon atoms in one molecule. The linear ones are small (L1 and L2) while the circular ones are bigger (D2 – D6). The small ones are volatile and difficult to measure since the time between sampling and analyzing is critical, they are also difficult to remove as their adhesion to activated carbon is weaker than the adhesion of the bigger ones.

Volatile organic compounds (VOCs) are chemical compounds (mostly gases) that are released from various organic and inorganic materials. VOCs can have deleterious short-term and long-term effects on the health of humans, as well as plants, animals, and the natural environment. It has also bad effects on the process itself such as clogging the membrane that separates CO_2 and CH_4 which in return affects the final product quality.

Nomenclature

D4 = Octamethyl-cyclo-tetra-siloxane
D5 = Dekamethyl-cyclo-penta-siloxane
D6 = Dodecamethyl-cyclo-hexa-siloxane

L2 = Hexamethyl-di-siloxane
L3 = Octamethyl-tri-siloxane
L4 = Decamethyl-tetra-siloxane
L5 = Dodecamethyl-cyclo-penta-siloxane

Siloxanes and VOCs analysis from different plants

Analysis of spend FerroSorp® S-samples from two different wastewater treatment plants and one biogas plant proof, that FerroSorp® S does not only remove H_2S but also some siloxanes and VOCs.

One plant in south west Germany is using a FerroSorp® S in their desulfurization units. A gas sample was taken at each step of the desulphurization process to be analyzed. The results in Table 1 show, that the FerroSorp® S in the first Desulphurizer unit removed most of the D4 and D5-siloxanes, meanwhile the second unit removed most of the Toluene.

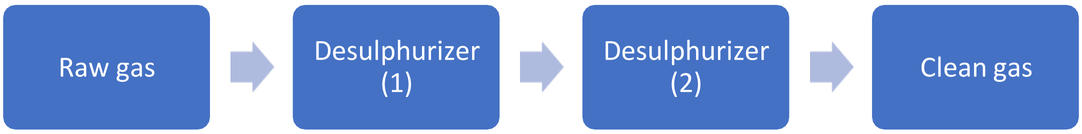

Figure 1: The process flow diagram of the desulphurization process in the watertreatment plant

Table 1: Concentration of selected siloxanes and Toluene in the gas at each stage

Component	Unit	Raw gas	Desulphurizer (1)	Desulphurizer (2)	Clean gas
Toluene	mg/m^3	4.5	3.9	3.7	< 0.2
D4	mg/m^3	0.1	< 0.1	< 0.1	< 0.1
D5	mg/m^3	2.3	0.2	0.2	0.1

In a biogas plant, one gas sample was taken from the raw gas before the desulphurizer unit and one more from the clean gas. The results confirm, that FerroSorp® S can remove D5 and to a lesser extent also D4. However, the results also show, that most of the two siloxanes passed the media.

Figure 2: The process flow diagram of the desulphurization process in a biogas plant

Table 2: Concentration of selected siloxanes D4 and D5 in the gas at each stage

Component	Unit	Raw gas	Clean gas
D4	ppbv	113	89.2
D5	ppbv	168	94.1

Another wastewater treatment plant has a filter filled with FerroSorp® S followed by two activated carbon filters. The three filters are in series as shown in the figure below. At this site, samples of the spent media were taken from each filter to analysis how many VOCs and siloxanes were adsorbed.

Figure 3: The process flow diagram of the desulphurization process in the watertreatment plant

Table 3: The Loading rate with VOCs and siloxanes of the adsorbents in each filter

Component	Unit	FerroSorp® S	Activated carbon (1)	Activated carbon (2)
Total VOCs	mg/kg	16.24	16045.52	5143.65
D4	mg/kg	0.16	950	600
D5	mg/kg	6.2 – 20.9	2,800	24,000
D6	mg/kg	2	480	280
L2	mg/kg	< 0.25	2.2	1.6
L3	mg/kg	< 0.25	0.53	2.5
L4	mg/kg	< 0.25	1.8	30
L5	mg/kg	0.66	< 0.25	< 0.25

Table *3* shows the amount of siloxanes and VOCs adsorbed by each of the adsorbents. Despite FerroSorp® S being in the first vessel in line, the loading rate was low compared to the subsequent activated carbon in the two lagging filters. For some components such as the total content of VOCs and D4 the difference between the activated carbon and the FerroSorp® S is around 3 powers of ten. Part of this comes from the operating conditions and part of it is because of the bigger surface area of activated carbon.

Still, the results confirm that FerroSorp® S can adsorb D4 to D6 as well as L5. The latter was removed by FerroSorp® S to a rather full extent. At the same time the more volatile siloxanes L2 – L4 were just bound by the activated carbon

Conclusion

The FerroSorp® S has the ability to adsorb Siloxanes, especially larger ones such as L5, D4 - D6. In contrast VOCs as well as volatile siloxanes such as L2 – L4 basically pass FerroSorp® S with little to no removal and can only be removed by using activated carbon or similar products.

At plants where only H_2S has to be removed, no matter if VOCs are present or not, FerroSorp® S is a superior product to activated carbon, because it doesn't lose significant binding capacities due to VOCs, unlike carbon would do.

However, if these compounds such as VOCs or siloxanes have to be removed and just one vessel is available, a good, broadly effective product such as activated carbon is recommended. Alas, this requires compromises in the performance. If there are two vessels in series available instead, FerroSorp® S for the removal of H_2S in the first filter and a special activated carbon in the lagging filter are a very good combination.

FerroSorp® S reacts selectively with H_2S, most other contaminants pass the adsorbent and therefore allow for a high loading rate of H_2S. Depending on their concentration, VOCs and siloxanes can significantly deteriorate the ability of expensive impregnated or doped activated carbon to bind H_2S. Thus, a combination of both adsorbents is often a very efficient way to reduce OPEX and increase the operating time of a system.