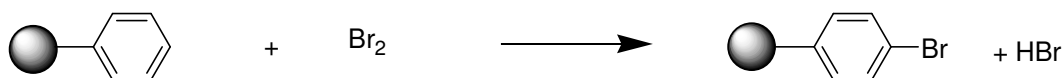


Technical Information

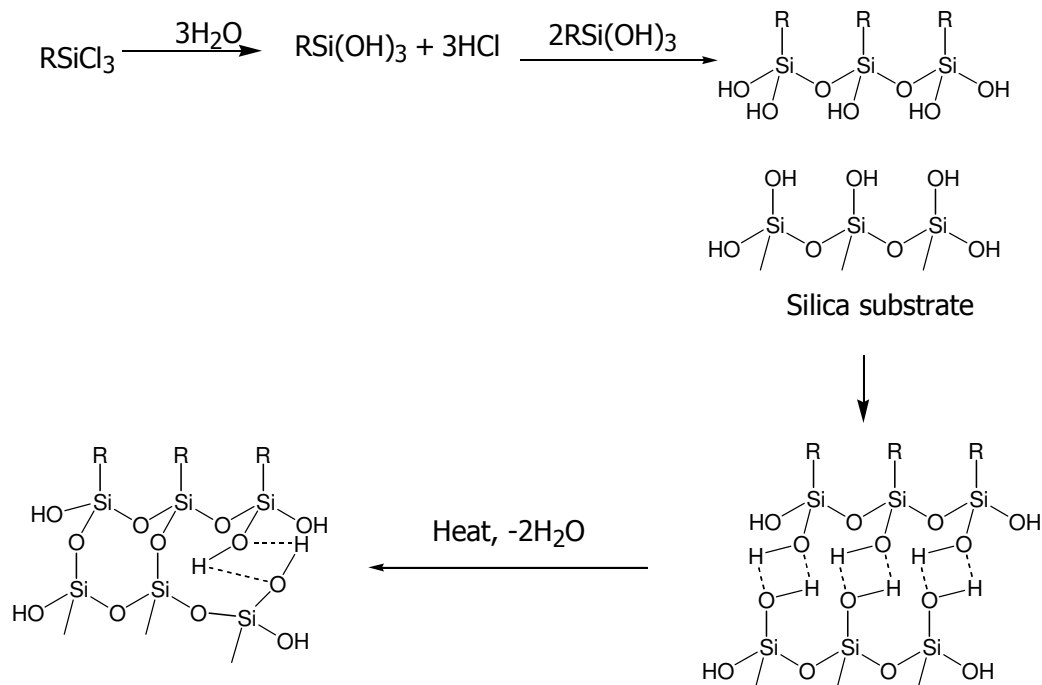
1) Bromination of organic polymers



The reaction here is the addition of bromine to the aromatic ring of a polystyrene polymer, catalysed by thallium (III) acetate to ensure reaction in the *para* position of the ring. This reaction is carried out at room temperature and pressure in 2.4 – 3Kg batches in a closed glass reaction vessel housed in a bunded fume cupboard under conditions defined by an ISO 9001:2008 work instruction. Loading and unloading of the reactor vessel is carried out with fume extraction. After an overnight reaction the mixture is heated to 75°C to drive off the reaction by-product, hydrogen bromide, and the product is washed *in situ* before drying under vacuum. The emissions from this reaction are principally hydrogen bromide, along with some fugitive emissions of VOCs (solvents used for purification), and the peak of emissions occurs during the 3 hour heating period. There is no active abatement system as the emissions are below the levels required for a low impact installation (reference H1v2_4_Biotage 2015 (2)). Fume extraction is installed under primarily under Control of Substances Hazardous to Health (COSHH) regulations, Health & Safety at Work Act 1974. Waste solvent is consolidated and collected by Environmental Resource Group.

This process takes a total of 3 days from start to finish, but emissions of HBr only occur during the first half of the process. This was carried out on 9 occasions in 2014 (23Kg start weight), and on 22 occasions in 2015 (61Kg start weight).

2) Chlorosilation

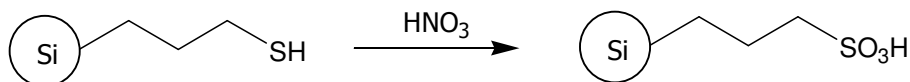


The reaction here is the addition of an organic chlorosilane to the surface of a silica particle, catalysed by imidazole. This reaction is carried out at 58°C and atmospheric pressure in batches ranging from 1Kg to 12Kg in a closed glass reaction vessel housed in a bunded fume cupboard under conditions defined by an ISO 9001:2008 work instruction. Loading and unloading of the reactor vessel is carried out with fume extraction. After an overnight reaction the mixture is washed *in situ* before drying. The emissions from this reaction are principally hydrogen chloride, along with some fugitive emissions of VOCs (solvents used for purification), and the peak of emissions occurs during the first 2 – 3 hours of the reaction. There is no active abatement system as the emissions are below the levels required for a low impact installation (reference H1v2_4_Biotage 2015 (2)). Fume extraction is installed under primarily under Control of Substances Hazardous to Health (COSHH) regulations, Health & Safety at Work Act 1974. Waste solvent is consolidated and collected by Environmental Resource Group.

A variation of this reaction involves using an alkoxy silane in place of the chlorosilane. The by product in this case is methanol, removed in the purification process.

This process takes a total of 5 working days from start to finish, but emissions of HCl only occur during the first 2 days of the process. This was carried out on 33 occasions in 2014 (229Kg start weight), and on 32 occasions in 2015 (241Kg start weight).

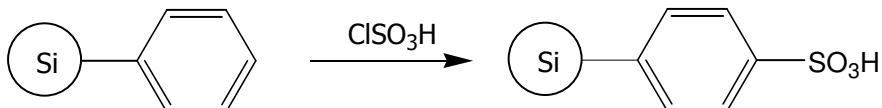
3) Oxidation of Si – Thiol



The reaction here is the oxidation of the thiol group on a bonded phase sorbent (prepared via the reaction above) with dilute nitric acid. This reaction is carried out at 50°C and atmospheric pressure in 6 – 7Kg batches in a closed glass reaction vessel housed in a bunded fume cupboard under conditions defined by an ISO 9001:2008 work instruction. Loading and unloading of the reactor vessel is carried out with fume extraction. After an overnight reaction the product is washed extensively before drying. The emissions from this reaction are oxides of nitrogen, mainly as NO₂, along with some fugitive emissions of VOCs (solvents used for purification), and the peak of emissions occurs during the first hour of the reaction. There is no active abatement system as the emissions are below the levels required for a low impact installation (reference H1v2_4_Biotage 2). Fume extraction is installed under primarily under Control of Substances Hazardous to Health (COSHH) regulations, Health & Safety at Work Act 1974. Waste solvent is consolidated and collected by Environmental Resource Group.

This process takes a total of 5 working days from start to finish, but emissions of NOX gases only occur during the first 2 – 3 hours of the process. This was carried out on 45 occasions in 2014 (265Kg start weight), and on 50 occasions in 2015 (287Kg start weight).

4) Sulphonation of sorbents



The reaction here is the sulfonation of the aromatic ring of a bonded phase sorbent using chlorosulfonic acid in dichloromethane. This reaction is carried out either at room temperature or at 40°C and atmospheric pressure in 2 – 3Kg batches in a closed glass reaction vessel housed in a fume cupboard under conditions defined by an ISO 9001:2008 work instruction. Loading and unloading of the reactor vessel is carried out with fume extraction. After an overnight reaction the reaction is quenched by pouring the mixture on to ice. The product is washed thoroughly before drying. The emissions from this reaction are principally hydrogen chloride, along with some fugitive emissions of VOCs (solvents used for purification), and the peak of emissions occurs during the first hour of the reaction quenching process. A small, laboratory size scrubber is used during the reaction to minimise the local effects of the HCl, but there is no active abatement system as the emissions are below the levels required for a low impact installation (reference H1v2_4_Biotage 2). Fume extraction is installed under primarily under Control of Substances Hazardous to Health (COSHH) regulations, Health & Safety at Work Act 1974. Waste solvent is consolidated and collected by Environmental Resource Group.

This process takes a total of 8 working days from start to finish, but emissions of HCl only occur during the first 2 days of the process. This was carried out on 7 occasions in 2014 (24Kg start weight), and on 4 occasions in 2015 (11Kg start weight).