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Original Article

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What Do Safety Data Sheets for Artificial Stone Products Tell Us About Composition? A Comparative Analysis with Physicochemical Data

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Abstract

Artificial stone (AS) is a composite material that has seen widespread use in construction, particularly for kitchen benchtops. However, fabrication processes with AS have been associated with serious lung disease. Safety data sheets (SDSs) aim to provide important information pertaining to composition and health risks. In the case of a complex mixture, SDSs may be problematic in terms of specific information on overall health risks. To assess this issue, we compared empirically determined mineral, metallic, and organic resin content of 25 individual AS products across six suppliers, with the corresponding SDS information. X-ray diffraction was used to quantitate the mineralogical components of AS samples, and X-ray fluorescence was used to estimate the metallic components. Organic material (resin content) was estimated using weight loss during calcination. Although the resin content for all AS samples was within the SDS-reported ranges, there was considerable variability in the crystalline silica content when comparing with supplier's SDS. Potentially toxicologically relevant metallic and mineral constituents were not reported. Some supplier SDSs were found to provide more information than others. Only one of the six suppliers provided crystalline mineral content other than silica, and only two suppliers provided any information about metals. There remains a limited understanding of lung pathogenesis from AS, and this study highlights the need for more comprehensive and standardized SDS information for risk assessment and management.

Keywords: artificial stone; composite stone; engineered stone; health risk; manufactured stone; safety data sheet; SDS; toxicity

What's important about this paper

Safety data sheets (SDS) are a key mechanism for communicating health and safety information of products, including for artificial stone (AS) products, which have been associated with accelerated silicosis among workers. This study compared empirically determined physicochemical data derived from 25 AS samples across 6 different suppliers with information provided in the SDS and found that many metallic and mineral constituents were not reported or not accurately reported on SDSs. More comprehensive information should be included in SDSs for AS products to facilitate effective risk communication and management.

Introduction

The safety data sheet (SDS) also known as a material safety data sheet is a hazard communication tool that exists to support the safe handling, use, disposal, and emergency management of specific products. SDSs provide important information on product constituents and potential health risks, especially when the product in question is of a toxic nature, a complex mixture, or an engineered product (Eastlake *et al.*, 2012; Ronald, 2012).

Artificial stone (AS), also known as engineered, reconstituted, manufactured, or composite stone, is a complex mixture. Exposure to respirable AS dust has been associated with accelerated silicosis and other health conditions (Leso *et al.*, 2019). Studies from multiple countries have reported an alarming incidence of lung disease in the AS industry, and this represents a global issue (Leso *et al.*, 2019; Rose *et al.*, 2019; León-Jiménez *et al.*, 2020; Wu *et al.*, 2020). With the popularity of AS as a cheaper and easy-to-handle alternative to natural stone slabs for the purposes of construction, in particular, kitchen benchtops, the associated burden on health in workers is predicted to increase in the coming years (Leso *et al.*, 2019). Health risks associated with AS are predominantly faced by the fabricators who engage in cutting, grinding, and polishing of the material (Hoy *et al.*, 2018; Glass *et al.*, 2022; Hoy, 2021). Initially, the toxicity of AS dusts was predicated on the high crystalline silica content in these products—up to about 90% crystalline silica by weight (Pérez-Alonso *et al.*, 2014; Paolucci *et al.*, 2015). While the high crystalline silica content in the dusts is still a major factor, further investigation has shown that there are other factors that may play a role in the pathogenesis and disease progression, such as the presence of certain metal ions (found in pigments) and organic resin content (Paolucci *et al.*, 2015; Pavan *et al.*, 2016; Di Benedetto *et al.*, 2019; Leso *et al.*, 2019). The contribution of these constituents to the toxicity of the AS dusts generated during fabrication is currently being explored, with the underlying toxicological mechanisms not yet well understood.

As far as we can determine, each AS manufacturer, importer, or supplier, hereafter referred to as supplier, produces a singular SDS for a range of products, detailing an approximate composition, usually limited to crystalline silica and resin content. A few suppliers provide further details regarding metal content and presence of silica polymorphs, but no precise details are provided regarding these constituents (Madden *et al.*, 2019). It is possible that compositionally, each individual AS product may be sufficiently different from other products from the same supplier, that they may present distinct and differing hazards to the fabricators.

We are not aware of any peer-reviewed papers that specifically address the SDSs of AS products. Therefore, the primary objective of this study was to identify the compositional differences between the AS products and compare them to the SDS-reported values, across a range of suppliers and products. Secondary to this, was the technical accuracy and sufficiency of supplier SDSs. However, this study does not evaluate other SDS information, such as handling and disposal. In addition, only organic resin-containing AS products were examined.

Methods

Sample selection and preparation

A total of 25 AS samples across 6 different suppliers (de-identified as A–F) were procured commercially. The individual samples and suppliers were chosen based on a combination of consumer popularity, colour, and design. To generate analytes representative of the base bulk material, laboratory conditions were used, as opposed to workshop fabrication processes. Each sample was initially cut using a wet diamond blade saw. The samples were then crushed to gravel size using a tungsten carbide jaw crusher. These pieces were subsequently comminuted under moderate conditions, to a mid-point size distribution of 10–18 µm, as described in Maharjan *et al.* (2021).

Sample analysis

Assessment of physicochemical properties of the AS samples, excluding organic resin, were determined by external National Association of Testing Authorities, Australia (NATA)-accredited laboratories (Maharjan *et al.*, 2021). Absolute metal content was determined by X-ray fluorescence (XRF) and crystalline mineral content was determined by X-ray diffraction (XRD), with a precision value at 0.001% and 1% by weight, respectively. The organic resin content for the samples was determined by weight loss after heating (calcination) to 600°C, using a calibrated Barnstead Thermolyne muffle furnace with CHY805 RTD thermometer, with a precision of 0.5% by weight.

Statistical analysis

Physicochemical results were analysed via the SPSS statistical software (IBM SPSS Statistics for Windows, Ver. 26, Armonk, NY: IBM Corp). High–low bar charts were generated to facilitate comparisons and highlight the range of values.

Results

The physicochemical compositions of the stone samples were compared with the SDSs obtained from the suppliers, and were current as of November 2021.

Assessment of supplier SDSs

As can be seen from Tables 1 and 2, the SDS-reported values of crystalline silica, resin, metals, and other mineral constituents were compared with analytically determined values of multiple unique AS products. The tables show that the supplier SDSs usually reported quartz, cristobalite, feldspar, titanium (in the form of titanium dioxide) as a weight percentage composition of the AS. The method of determination of the constituents was not described in any supplier SDS.

Significant variability in reported constituents was noted, with little consistency between the SDSs of different suppliers. Quartz and cristobalite percentages were reported separately in SDS from supplier A, while they were reported as a combined value in SDS-B and D. Additionally, SDS-D, E, and F did not report cristobalite concentration at all, even though it was determined to be present. Furthermore, SDS-B, did not specify a singular concentration range of quartz and cristobalite in their products, instead opting to split their products into three different ranges.

With regard to crystalline minerals and metal content, only supplier A reported the presence of feldspar, while only suppliers A and B reported the presence of titanium. Reporting of organic resin content was limited to suppliers A–D.

Table 1. Comparison of empirically determined silica, mineral, and resin constituents of AS products with SDS-reported values.

	Supplier	Product	Silica (% of total crystalline content)	Other minerals (% of total crystalline content)	Resin (%)
SDS-reported composition	A	SDS (all products)	**Quartz (24–92%), cristobalite (0–50%)**	**Feldspar (0–15%)**	**Polyester resin (7–15%)**
Analysed AS sample		AS1	Quartz (89%), cristobalite (0.4%)	Albite/feldspar (3%), magnetite (0.8%), haematite (0.2%), other (6.6%)	Polyester resin (9.7%)
		AS2	Quartz (59%), cristobalite (25%)	Albite/feldspar (10%), rutile[a] (5.6%), other (0.4%)	Polyester resin (11.1%)
		AS3	Quartz (98%)	Albite/feldspar (0.2%), rutile[a] (1.6%), other (0.2%)	Polyester resin (9%)
		AS4	Quartz (96%)	Albite/feldspar (0.5%), rutile[a] (4%)	Polyester resin (9.4%)
		AS5	Quartz (94%)	Albite/feldspar (6.2%)	Polyester resin (11.2%)
		AS6	Quartz (99%)	Albite/feldspar (0.03%), rrutile[a] (0.9%), other (0.07%)	Polyester resin (8.9%)
		AS7	Quartz (90%)	Albite/feldspar (6.9%), rutile[a] (2%), other (1.1%)	Polyester resin (10.9%)
		AS8	Quartz (98%)	Albite/feldspar (1%), rutile[a] (0.8%), other (0.2%)	Polyester resin (11.4%)

Table 1. Continued

Supplier	Product	Silica (% of total crystalline content)	Other minerals (% of total crystalline content)	Resin (%)
SDS-reported composition B	**SDS (all products)**	**Quartz and cristobalite[c] (1–10%/10–50%/51–90%)**	**n/a**	**Polyester resin (5–15%)**
Analysed AS sample	BS1	Quartz (56%), cristobalite (24%)	Albite/feldspar (2.2%), rutile[a] (0.7%), other (17.1%)	Polyester resin (12.6%)
	BS2	Quartz (92%)	Haematite (0.4%), other (7.6%)	Polyester resin (8.4%)
	BS3	Quartz (19%), cristobalite (47%)	Albite/feldspar (6%), rutile[a] (0.8%), other (27.2%)	Polyester resin (12.9%)
	BS4	Quartz (23%), cristobalite (43%)	Albite/feldspar (7.2%), rutile[a] (0.5%), other (26.3%)	Polyester resin (14.3%)
	BS5	Quartz (70%), cristobalite (30%)	Albite/feldspar (0.2%)	Polyester resin (12.6%)
	BS6	Quartz (92%), cristobalite (7.3%)	Rutile[a] (0.5%), other (0.2%)	Polyester resin (12.7%)
	BS7	Quartz (65%), cristobalite (24%)	Albite/feldspar (11.4%)	Polyester resin (11.3%)
	BS8	Quartz (98%)	Rutile[a] (1.9%), other (0.1%)	Polyester resin (10.3%)
SDS-reported composition C	**SDS (all products)**	**Quartz (>90%)**	**n/a**	**Organic polymer[b] (<10%)**
Analysed AS sample	CS1	Quartz (98%)	Rutile[a] (1.8%), other (0.2%)	Polyester resin (11.9%)
	CS2	Quartz (96%)	Rutile[a] (4%)	Polyester resin (9.9%)
SDS-reported composition D	**SDS (all products)**	**Quartz and cristobalite (70–95%)**	**n/a**	**Polyester resin (5–15%)**
Analysed AS sample	DS1	Quartz (90%), cristobalite (0.3%)	Haematite (0.1%), other (9.6%)	Polyester resin (9.7%)
	DS2	Quartz (76%), cristobalite (23%)	Rutile[a] (0.6%), other (0.4%)	Polyester resin (10.8%)
SDS-reported composition E	**SDS (all products)**	**Quartz (>89%)**	**n/a**	**n/a**
Analysed AS sample	ES1	Quartz (99%)	Other (1%)	Polyester resin (14.6%)
	ES2	Quartz (99%)	Other (1%)	Polyester resin (12.6%)
	ES3	Quartz (99%)	Magnetite (0.01%), other (0.09%)	Polyester resin (12.7%)
SDS-reported composition F	**SDS (all products)**	**Quartz (>88%)**	**n/a**	**n/a**
Analysed AS sample	FS1	Quartz (10%), cristobalite (90%)	None	Polyester resin (12.2%)
	FS2	Quartz (78%), cristobalite (16%)	Rutile[a] (5.6%), other (0.4%)	Polyester resin (14.3%)

The precision of XRD was approximately 1% by weight, and for resin it was 0.5% by weight.
[a]Rutile is primarily composed of titanium dioxide.
[b]The polyester resin percentage range was not indicated in the product SDS by supplier C, and was instead estimated using the data provided in the SDS.
[c]This quartz and cristobalite content combined was segregated into three categories by supplier B, which are then indicated on the individual products.

Table 2. Comparison of empirically determined metallic constituents of AS products with SDS-reported values.

	Supplier	Product	Metals (%)
SDS-reported composition	A	**SDS (all products)**	**Titanium (0–2.4%)**[a]
Analysed AS sample		AS1	Fe (0.5228%), Al (0.3144%), Ti (0.0083%), Mn (0.008%), Cr (0.0013%), Cu (0.001%), Ni (0.0009%), Co (0.009%), Pb (0.0001%)
		AS2	Fe (0.05%), Al (1.33%), Ti (1.73%), Mn (<0.0078%), Cr (0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.004%), Pb (0.002%)
		AS3	Fe (<0.01%), Al (0.26%), Ti (0.863%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.01%), Pb (<0.001%)
		AS4	Fe (0.06%), Al (0.2593%), Ti (0.3056%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.008%), Pb (0.002%)
		AS5	Fe (0.05%), Al (0.471%), Ti (0.048%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.008%), Pb (0.001%)
		AS6	Fe (<0.01%), Al (0.2011%), Ti (0.773%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.008%), Pb (0.001%)
		AS7	Fe (0.04%), Al (1.265%), Ti (0.791%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.006%), Pb (0.002%)
		AS8	Fe (0.02%), Al (0.365%), Ti (0.156%), Mn (<0.0078%), Cr (0.001%), Cu (0.003%), Ni (<0.001%), Co (0.014%), Pb (0.003%)
SDS-reported composition	B	**SDS (all products)**	**Titanium (0–1.5%)**[a]
Analysed AS sample		BS1	Fe (<0.0035%), Al (0.2567%), Ti (0.2925%), Mn (<0.0002%), Cr (0.0005%), Cu (0.0002%), Ni (0.0003%), Co (0.0054%), Pb (0.0002%)
		BS2	Fe (0.0528%), Al (0.2048%), Ti (0.0252%), Mn (0.0009%), Cr (0.0005%), Cu (0.0004%), Ni (0.0003%), Co (0.0074%), Pb (0.0002%)
		BS3	Fe (0.0112%), Al (0.4642%), Ti (0.3588%), Mn (0.0002%), Cr (0.002%), Cu (0.0002%), Ni (0.0002%), Co (0.006%), Pb (0.0001%)
		BS4	Fe (0.01%), Al (0.7156%), Ti (0.1882%), Mn (<0.0002%), Cr (0.001%), Cu (0.0002%), Ni (0.0002%), Co (0.0056%), Pb (0.0002%)
		BS5	Fe (0.02%), Al (0.2858%), Ti (0.0599%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.005%), Pb (0.002%)
		BS6	Fe (<0.01%), Al (1.154%), Ti (0.174%), Mn (<0.0078%), Cr (0.002%), Cu (<0.001%), Ni (0.001%), Co (0.006%), Pb (0.001%)
		BS7	Fe (0.01%), Al (1.403%), Ti (0.791%), Mn (<0.0078%), Cr (0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.006%), Pb (0.001%)
		BS8	Fe (0.15%), Al (0.2329%), Ti (0.1139%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.006%), Pb (0.002%)
SDS-reported composition	C	**SDS (all products)**	**n/a**
Analysed AS sample		CS1	Fe (<0.01%), Al (0.1482%), Ti (0.2217%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.005%), Pb (0.001%)
		CS2	Fe (0.02%), Al (0.4023%), Ti (0.5454%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.003%), Pb (0.003%)
SDS-reported composition	D	**SDS (all products)**	**n/a**
Analysed AS sample		DS1	Fe (0.0881%), Al (0.2287%), Ti (0.0779%), Mn (0.0024%), Cr (0.0008%), Cu (0.0004%), Ni (0.0009%), Co (0.0115%), Pb (0.0002%)
		DS2	Fe (0.02%), Al (0.1323%), Ti (0.1498%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.006%), Pb (0.002%)

Table 2. Continued

	Supplier	Product	Metals (%)
SDS-reported composition	E	**SDS (all products)**	**n/a**
Analysed AS sample		ES1	Fe (0.06%), Al (0.1376%), Ti (0.024%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.009%), Pb (0.003%)
		ES2	Fe (<0.01%), Al (0.1958%), Ti (0.5334%), Mn (<0.0078%), Cr (0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.007%), Pb (0.003%)
		ES3	Fe (0.22%), Al (0.2488%), Ti (0.012%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (<0.001%), Co (0.004%), Pb (0.001%)
SDS-reported composition	F	**SDS (all products)**	**n/a**
Analysed AS sample		FS1	Fe (0.02%), Al (0.0688%), Ti (0.0539%), Mn (<0.0078%), Cr (0.005%), Cu (<0.001%), Ni (0.009%), Co (0.007%), Pb (0.002%)
		FS2	Fe (<0.01%), Al (0.0582%), Ti (1.2825%), Mn (<0.0078%), Cr (<0.001%), Cu (<0.001%), Ni (0.002%), Co (0.006%), Pb (0.002%)

The precision for XRF analysis had an upper limit of 0.001% by weight.
[a]Values for titanium content were extracted from the values provided by the SDS regarding titanium dioxide content.

Comparison of constituents

Empirically determined physicochemical data pertaining to the AS samples given in Tables 1 and 2, apart from confirming the presence of quartz, cristobalite, and feldspar, XRD also highlight the presence of crystalline rutile, magnetite, and haematite in some samples.

The XRF data in Table 2 relate to iron, aluminium, titanium, manganese, chromium, copper, nickel, cobalt, and lead. These metals were selected due to known toxicology.

All AS products contained organic material, which was consistent with the polyester resin reported in supplier SDSs (A–D). Supplier C did not specify the type of resin.

Comparison of concentrations

As seen in Tables 1 and 2, most SDS-defined components, i.e. quartz, cristobalite, feldspar, titanium, and organic resin, fell within the ranges specified by the supplier SDSs. However, it is also noted that the SDSs had unusually wide ranges for each constituent.

Despite these wide ranges, quartz and cristobalite content for samples 3, 4, 5, 6, and 8 of supplier A, and samples 2, 5, 6, and 8 of supplier B, were outside the SDS-specified compositional range, i.e. higher concentrations.

Fig. 1 depicts the variance in the constituents that compose AS products across different products under a singular supplier, as well as across different suppliers. Graphical analysis (Fig. 1) shows that resin in AS products within and across suppliers maintained a narrow margin and was relatively consistent. However, with regard to quartz and cristobalite, prominent differences were observed across the suppliers, with some maintaining a tighter margin of quartz and cristobalite content in their samples (C, D, and E), while others had wide variances within their products (B and F). Similar results were also observed for rutile, where samples from suppliers A and F had wider ranges compared with other suppliers.

Similar to mineral content, metallic content was also observed to have wide intra- and inter-supplier variability (Supplementary Fig. S1, available at *Annals of Work Exposures and Health* online). This may relate to colour differences across products (Maharjan *et al.*, 2021).

Discussion

To achieve consumer-driven demand for diversity in colour and design, AS products comprise various minerals, pigments, and bonding resins. Marhajan *et al.* (2021) report a correlation of the reflected brightness of the stone with iron and manganese content. Such metals may enhance lung toxicity from crystalline silica (Castranova *et al.*, 1997; Fubini and Fenoglio, 2007). Along with uncertainty regarding the role of inhaled resin in lung pathogenicity, it can be argued the SDSs should include more information on AS constituents for risk assessment, management, and epidemiology purposes.

This study focussed on SDSs and empirically determined composition information for a range of commercially available AS products and across a range of suppliers. There are three major findings of this study. Firstly, there appears to be variability in the way

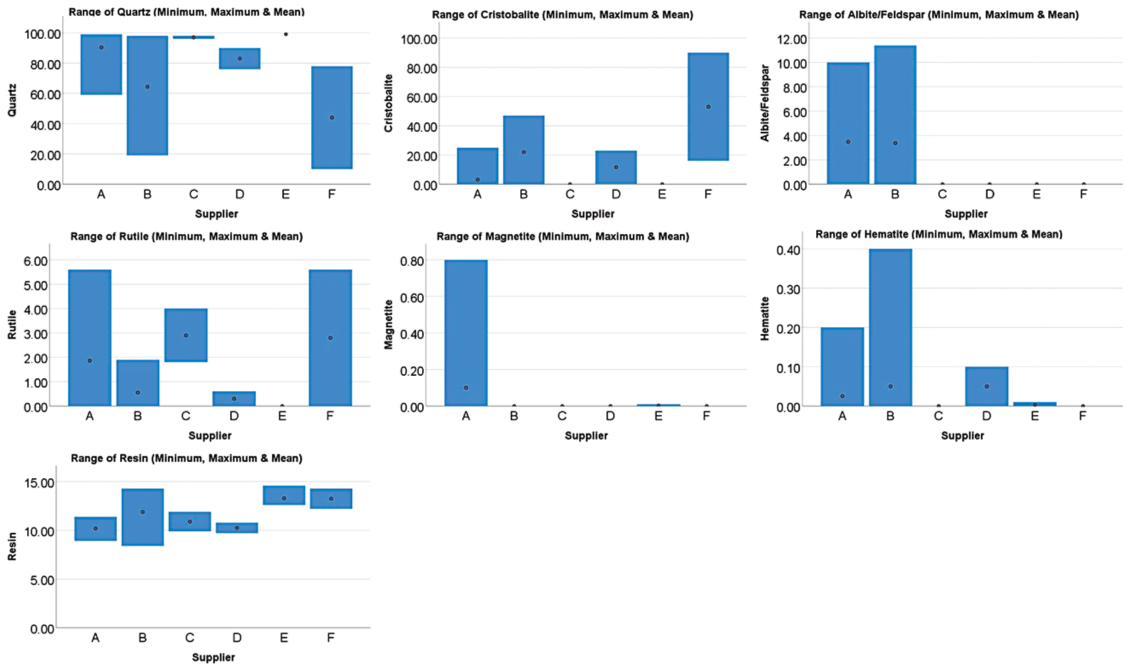

Figure 1. High–low plots depicting variance in the ranges (in %) of crystalline mineral and resin constituents across different suppliers. # where compositional values were less than the limit of detection of XRD, half of the limit of detection was considered as the value, for the figures presented.

composition is reported in the SDSs of different suppliers. Secondly, SDSs had limited information on mineralogical and metallic components (only titanium reported) in the AS products. Thirdly, the compositional ranges provided in the supplier SDSs do not strictly apply to all products, despite the wide ranges being reported.

Most of the supplier SDSs only provided a combined value for crystalline silica. While both quartz and cristobalite are polymorphs of crystalline silica, some studies have suggested that they may have differing bioreactivity owing to their differing surface chemical structure (Mossman and Glenn, 2013; Nattrass *et al.*, 2017; Vuong *et al.*, 2017). Therefore, individual reporting of the two silica polymorphs may be of value, from a health risk perspective.

Regarding other crystalline mineral content, only supplier A reported the presence of feldspar, which is a non-specific group of aluminosilicate minerals. In our XRD analyses, we found albite (a plagioclase feldspar) to be common. However, the exact role of aluminium in inflammatory processes is uncertain (Hornung *et al.*, 2008; Maharjan *et al.*, 2021). We also found rutile (primarily titanium dioxide) and apart from nanosized titanium dioxide, rutile dust is not considered to be highly toxic (Ferin and Oberdörster, 1985). Magnetite and haematite have been linked to adverse biological effects in some *in vitro* and animal studies (Das *et al.*, 1983; Rafieepour *et al.*, 2019). Notably, none of the SDSs reported the presence of magnetite and haematite.

All the suppliers SDSs either explicitly reported the presence of inorganic pigments or indicated the presence of colourants in their products. However, the exact pigments used in the AS samples were not identified in the SDSs nor in our analyses. Nevertheless, iron-containing pigments are common and can cause oxidative stress and DNA damage (Ferin and Oberdörster, 1985; Linnainmaa *et al.*, 1997; Weinberg, 1999; Huang, 2003). Some of the reported metals in Table 2 are either known or probable carcinogens, particularly upon inhalation (Kasprzak *et al.*, 2003; Wang *et al.*, 2017; Lison *et al.*, 2018). Manganese has been highlighted as a neurotoxin (Normandin and Hazell, 2002).

The presence of cobalt can also be attributed to the sample preparation process which used tungsten carbide milling (Yamasaki, 2018). This would explain the presence of cobalt in all AS samples.

This study has a number of strengths. Multiple products from each supplier were evaluated. The AS samples were assessed using various analytical methods to quantify components of potential health concern. There are also a few limitations of the study. Firstly, the samples generally underwent single analysis for each AS product. However, approximately 15% of the total were sent to a different external laboratory for quality control purposes and these returned similar XRD, XRF, and organic resin results. Secondly, analysis of metal content focussed on identification and not speciation of the metals. Thirdly, the study was limited to traditional AS compositions, rather than newer lower silica and resin free products. Nevertheless, many of the same SDS information issues are likely to apply. Finally, as this study was aimed at assessing the material composition of the AS, it does not take into account the composition of dusts generated during fabrication processes.

This study highlights the limitations of current AS SDSs with regard to reporting of metallic and mineral constituents. However, are these metallic and mineral components important enough and in sufficient quantity to be reported, from a health and hygiene perspective? Current literature acknowledges that the exact underlying mechanisms behind the toxicity of AS dusts are not completely understood (Ophir *et al.*, 2016; Pavan *et al.*, 2016; Di Benedetto *et al.*, 2019; Hoy, 2021). Even though metals were minor constituents in the bulk material, the presence of metals on the dust surface is important. Overall, AS is a complex mixture, and it would be prudent to report a wider range of constituents than current practice.

The observed inconsistency between supplier SDSs also raises the question of quality. The methods used to arrive at the components and their concentrations in the products, are not elaborated upon in any of the supplier SDSs examined. Whether the values provided are results of direct physicochemical testing in all cases, or estimates calculated through other means is not known.

While guidelines and codes of practice for preparations of SDSs do exist, they provide a great degree of leeway (Lerman and Kipen, 1990). An expert consensus on a standard for AS SDSs, determined and driven by occupational health professionals, is one possible approach to this issue. AS SDS, prepared by suppliers, in conjunction with an occupational health professional and a standardized guideline for items to be reported, may help bridge the current gap that exists, in relaying sufficient health and safety information regarding AS to the users.

The issues surrounding existing methods of SDS development and reporting regarding complex composite materials have been previously highlighted in the case of engineered nanomaterials (Eastlake *et al.*, 2012). Ideally, a solution to this issue could be to prepare individual SDSs for each product, taking into account the variation in composition between the AS products, to accurately reflect the potential differential hazard.

Conclusion

With a growing number of AS products in the market, and uncertainty as to the molecular pathogenesis from inhalation of dust, consideration should be given to the improvement and standardization of SDS. SDS information is important for risk assessment and management, and could be better targeted by encompassing information on silica polymorphs, mineral constituents, metals, and resin.

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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Authors' contributions

C.K. and D.P. were engaged in all aspects, including conceptualization, data compilation, interpretation, and drafting of the manuscript. S.G. contributed to conceptualization and data interpretation. T.H. was involved in the physicochemical characterization of AS samples. All authors critically reviewed the manuscript.

Conflict of interest

None declared.

Data availability

The data underlying this article are available in the article and in its online supplementary material.

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