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Characterisation of scale products formed on the heat-exchanger surfaces in the Bayer process

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Vast quantities of bauxite ore, used for the production of alumina (Al_2O_3) via the Bayer process, contain appreciable concentrations of reactive silicates. Secondary precipitation of these silicates within Bayer plants results in deleterious scale formation consisting largely of aluminosilicate and titanate phases, with resulting losses of caustic soda and decreased heat transfer efficiency. In spite of numerous related laboratory studies, an insufficient amount of data has been published regarding the characterisation of these industrial scales, which can provide vital information pertaining to the mechanism of scale growth. SEM, XRD and EDS analyses were carried out on selected scale samples removed from the inside wall of plant equipment across a number of alumina refineries. SEM images of the cross-section of the industrial scale samples were carried out to explore compositional changes with depth from the wall. High amorphous content of the industrial samples were calculated using XRD Rietveld analysis and the addition of corundum was used as an internal standard. Therefore, XANES at both the Al and Si K-edges was applied to identify the amorphous phases, in conjunction with XRD and EDS results, which were demonstrated to consist predominantly of poorly crystallised sodalite. There is strong correlation between the amorphous content and the scale microstructure. High amorphous content appears to indicate nucleation of the scale occurred on the internal surfaces of the heat exchangers. Low amorphous content suggest the desilication product particles form in the slurry during desilication and then deposit on the heat exchange surfaces.

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