

Characterization of solids in froths, diluted bitumen products, tailings, and rag layers from a gravity-settling naphtha based froth treatment pilot operation

Patrick H.J. Mercier*¹, Samson Ng², Judy Kung¹, Bussaraporn Patarachao¹, David M. Kingston¹, Bryan D. Sparks¹, Luba S. Kotlyar¹, Yvon Le Page¹, Daniel Tyo¹, Andre Zborowski¹, Gregory M. Marshall¹, Gilles Robertson¹, Floyd Toll¹, and Thom McCracken¹

¹*National Research Council Canada, NRC Energy, Mining and Environmental Portfolio, Ottawa, Ontario, Canada* ²*Syncrude Canada Ltd., Research and Development Centre, Edmonton, Alberta, Canada*

Inlet froth feed, outlet tailings streams and diluted bitumen products (dilbits) from a gravity-settling pilot operation were analyzed for quantitative characterization of solids properties. The rag layers which form at the oil–water interface in naphtha based froth treatment processes were analyzed as well. The gravity-settling pilot unit can be run in two modes, by-pass and re-cycle, and the rag layers from the two modes of operation were compared. The purposes of this study were two-fold: (a) to determine the nature of solid particles that preferentially collect at the water–diluted bitumen interface, and (b) to characterize the mineralogy, wettability (degree of hydrophobicity-hydrophylicity), and particle size distribution (PSD) of solids from key streams of the gravity-settling process in comparison to the centrifuge process. This represents the most advanced quantitative analysis of solids properties ever performed on process streams from oil sands naphtha based froth treatment processes.

The main results from this work were as follows. Rag layers formed in the gravity-settling pilot experiments in a way that potentially encumbered bitumen recovery and the efficient transport of solids into the tailings stream. The rag layers were unstable (i.e., were easily disrupted by gentle mixing) and eventually separated into an upper layer, a water layer, and a lower layer after prolonged standing. These three components were quantitatively separated from each rag layer and analyzed. Eventually, after a long undisturbed standing period, the upper layer further separated into a dilbit-like (top layer) and a water-rich, gel-like layer (bottom layer). The structure of this gel appears to form a barrier that impedes the transfer of solids into the tailings. The amount of rag layer formed when fine tailings were re-cycled was much greater than in a once through process. An interfacial toluene/water (T/W) separation technique, developed and practiced at the NRC, was used to quantitatively fractionate the samples into up to four fractions (in order of decreasing water wettability): hydrophilic solids (HPS) going with the aqueous phase; intermediate solids (IS) loosely held at T/W interface; biwettable organic-rich solids (ORS) remaining strongly held at T/W interface; and solids (denoted as HSCS) remaining dispersed in the oil/toluene phase that could be separated only by high speed centrifugation (HSC). The mineralogical compositions of these four types of wettability fractions were very similar, regardless of sample source (froths, dilbits, tailings or rag layers). The upper and lower rag layers were dominated by ORS-type solids in which heavy minerals (zircon, rutile, anatase, pyrite, siderite) were the main contributors. Generally, a decrease in quartz content and an increase in the contribution of clays (K, Al) and [Fe,Mg,Ca]-bearing minerals was observed as the particle size decreases. Whereas it is generally assumed that the solids contribution to rag layers in froth treatment processes arises mainly from <45 µm size materials, particularly clays, it was discovered here that the rag layers were dominated by ORS-type solids including significant amounts of >45 µm size materials. Indeed, the 75–150 and 45–75 size fractions represented a considerable proportion of solids in the rag layers and most of the titanium oxides (rutile, anatase) and zircon were always concentrated in these two size fractions, irrespective of the process stream.