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Tittle: Experimental and Simulation-Based Study of Acid Gas Removal in Packed Columns with Different Packing Materials

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General Comments:

The paper title **Experimental and Simulation-Based Study of Acid Gas Removal in Packed Columns with Different Packing Materials** a well-structured and comprehensive study combining both experimental and simulation approaches to investigate the removal efficiency of gaseous pollutants (H_2S and CO_2) using different packing materials. The experimental validation complemented by ASPEN Plus simulation adds strong credibility and practical relevance to the findings. The results are clearly presented, demonstrating meaningful trends regarding the effects of gas flow rate, column diameter, and packing type on removal performance. However, while the study provides valuable insights into process design and optimization, the discussion could improve, including the following comments:

1. Highlight the benefit from deeper interpretation of the underlying mass transfer mechanisms, especially the distinct behaviors of H_2S and CO_2 under similar operating conditions. Including a more detailed comparison with previous literature would also strengthen the novelty and contextual significance of the work.
2. A clearer explanation of the simulation assumptions, boundary conditions, and model validation metrics would enhance the reproducibility and scientific rigor (see methodology section).
3. Although the work claims novelty in combining simulations and experiments, recent studies have also explored hybrid approaches. A more critical literature positioning is needed to clearly delineate what

aspect of integration or insight truly distinguishes this study. (See Page 3 Lines 125-137)

4. The manuscript should clarify how the operational parameters listed in Tables 1 and 2 were determined. Were these values obtained from experimental measurements, literature references, or simulation-based optimization? Providing this information is essential to ensure the reproducibility and validity of the study.
5. While the modeling and validation approach is clearly described, the section would benefit from a more rigorous justification of the scaling methodology and model assumptions used when extending simulations to larger column diameters. It remains unclear whether hydrodynamic and mass-transfer parameters were appropriately adjusted to reflect scale-dependent effects such as liquid maldistribution, pressure drop, or non-ideal flow patterns. Without explicit discussion or validation at larger scales, the reliability of the scale-up predictions and the resulting performance comparisons between packing types may be overstated or insufficiently supported. See Sub Section 2.2
6. Sub-section 3.1 remains largely descriptive and lacks sufficient quantitative analysis to substantiate the stated performance relationships. The discussion would benefit from including experimental or modeled data, such as measured mass transfer coefficients, pressure drops, or effective interfacial areas to validate the claims about flow maldistribution and hydraulic superiority. Additionally, the explanation assumes that the observed effects are solely due to surface area and void fraction, without considering other influential factors such as wettability, packing geometry, or liquid distribution quality. A more rigorous correlation or mechanistic linkage between structural parameters and the measured mass transfer performance would strengthen the scientific validity and general applicability of this section.
7. The caption in Fig. 2 states that experimental data are available only for the 10 cm diameter column. However, the plotted figure shows multiple

experimental data markers (“×”) across all gas flow rates, which visually overlap with all simulated lines. This may incorrectly imply that experimental measurements exist for other diameters (20 cm and 40 cm). The legend and figure labeling must be revised to clearly distinguish which data points correspond to experimental versus simulated results. Additionally, the use of identical black “×” markers at all flow rates without differentiation causes confusion about which data points belong to the 10 cm experimental case. Distinguishing experimental data by color, shape, or by plotting them separately (e.g., as inset or secondary figure) would improve clarity. Please also check Figs. 4 and 6

8. The explanation of Fig. 9 remains largely qualitative and lacks quantitative validation. The authors should substantiate these claims by providing supporting correlations, dimensionless analysis, or experimental uncertainty ranges to confirm that the observed trends are not merely empirical but grounded in transport phenomena theory.
9. The discussion section would benefit from a more thorough comparison with previously published studies. At present, the absence of reference-based benchmarking makes it difficult to assess how the reported trends align with or diverge from established findings in the literature. Incorporating such comparative analysis would not only enhance the scientific rigor of the discussion but also help validate the reliability and broader relevance of the results within the existing body of knowledge.