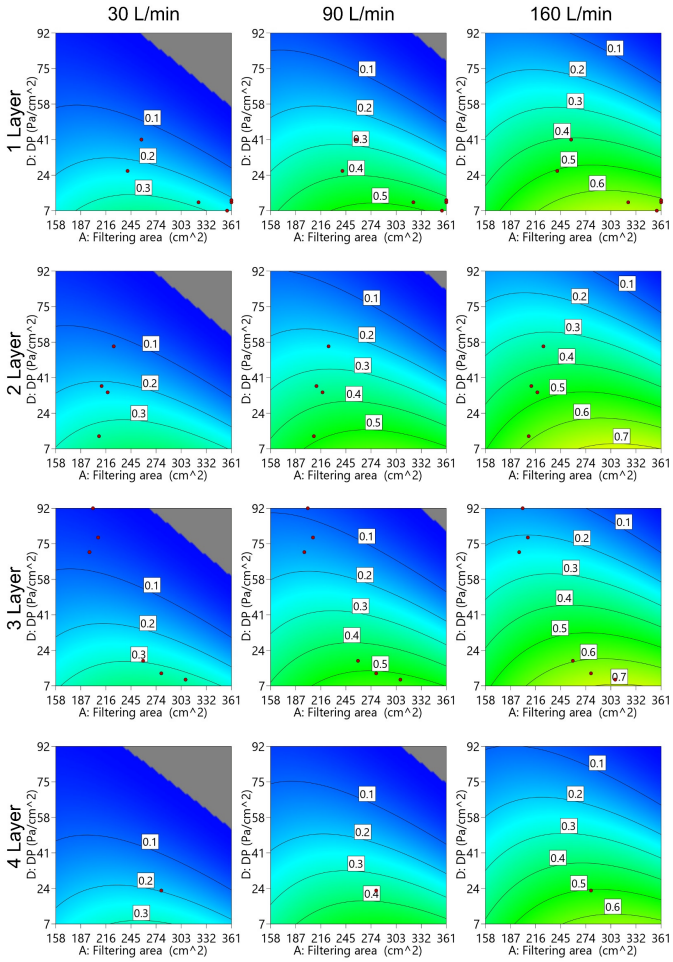

Fig. 9. TFE values predicted by the RSM model for a mask with no meltblown layer in the filter and no nosepiece. Results are shown at three different flow rates (30, 90, and 160 L/min). Experimental datapoints are represented with red dots.

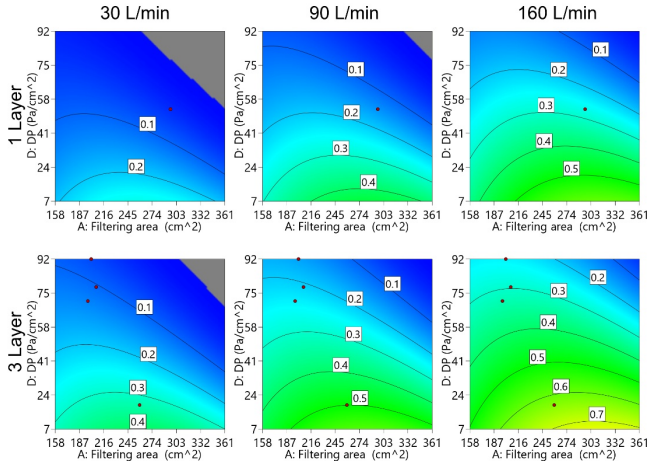

Fig. 10. TFE values predicted by the RSM model for a mask with no meltblown layer in the filter, but a nosepiece in place. Results are shown at three different flow rates (30, 90, and 160 L/min). Experimental datapoints are represented with red dots.

confirmed our previous results on a smaller number of mask models [27], and it is consistent with the opposite behavior observed for the fraction of air leaking at the face seal, that is reduced at higher flow rates [43], [58]. This is a consequence of the complementary role of Q_{mask} and Q_{leak} in (1) and the role of Q_{mask} in the definition of F_{mask} (5) and TFE (6). It is important to emphasize that since TFE is a percentage measure of outflowing filtered air, the increase of TFE at higher flow rate, which could be typical of heavy breathing or loud vocalization, is not enough to cause a decrease of the absolute amount of aerosol emitted by the mask wearer. In fact, such activities have been associated with greater aerosol emission [59].

The analysis of breathability and TFE data showed a negative monotonic correlation at all flow rates, in particular at 160 L/min. The surface response model confirmed this trend, producing a large negative linear coefficient associated with DP. This reinforced the concept that highly breathable materials can improve the mask efficiency, facilitating the passage of the airflow through the mask filter and avoiding leakages, supporting the results previously obtained by Chiera et al. [43]. It is interesting to note that no significant difference in TFE existed between community and SMs, with some CMs (e.g., CM03) showed higher TFE values than many of the SMs tested in this study. This ensues from a less marked contribution of BFE on TFE calculation than F_{mask}. Indeed, although many CMs have moderately lower BFE values than a typical SM, most of them, in our mask sample, were also characterized by far lower DP values. As previously reported [43], breathability has a strong correlation with the fraction of airflow leaking at the face seal since leakage is facilitated when the airflow encounters a high filter resistance [24], [60]. As leakage is complementary to F_{mask}, which is the dominant factor on TFE, a better breathability may significantly enhance TFE.

The effect of DP on TFE has been analyzed in other works, reinforcing the importance of tissue breathability and a proper fit. For instance, Freeman et al. [21] tested aerosol overall FE of masks mounted on a manikin head at constant inflow and outflow rates, in sealed and unsealed configurations. While in sealed conditions fabric weight and thickness correlated positively with FE, the performance for unsealed configurations was remarkably inferior, evidencing the role of leakage in reducing the benefit of the sole material FE of a mask in real world usage. Pan et al. [34] evaluated face covering for material FE and inward/outward protection efficiency at different aerosol sizes, confirming that material FE can misrepresent the protection efficiency of a worn mask due to fitting. Protection efficiency varied also with aerosol size, being above 50% and 75% for particles larger than 1 μm for a homemade CM and an SM, respectively, but decreasing consistently for smaller aerosols. Lindsley et al. [35] studied how performance metrics such as FE, fit factor, and airflow resistance can represent the actual efficiency of a mask, measured as collection efficiency of artificial aerosol emitted from a manikin head form with pliable skin. Collection efficiency of exhaled aerosols ranged 42%–99% for medical masks and 17%–66% for CMs. Correlation of collection efficiency with FE, fit factor, and airflow resistance was significant but not strong enough to make these alternative performance metrics good predictors for the actual performance, with variability in seal leakage and particle size considered as the interfering