

Electric Space-Charge Driven Process for Reducing Respirable Airborne Dust from Tree-Nut Harvesting Machines

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Abstract - Tree nuts such as almonds, walnuts and pecans are routinely mechanically harvested by: 1) vibrationally dislodging the attached in-hull nuts from the trees; b) sweeping and blowing them into windrows along with extraneous vegetative and soil matter; and c) aerodynamically separating the nuts from the waste matter by a high-volume, high-velocity air plume. The exhausted air plume disperses into the ambient atmosphere very high concentrations of respirable-size dust particles in the PM₁₀ and PM_{2.5} ranges of particulate matter. Often this area-wide dust emission causes community-health issues as US EPA ambient air-quality standards are exceeded. Abatement becomes necessary at the site of emission, *i.e.*, on the mobile, self-powered mechanical harvesting machine. Our work has developed a cyclonic-separation process, as optimized by CFD modeling, for removing PM₁₀ dust, and several electrostatics-based processes for abating PM_{2.5} dust. Conventional electrostatic-precipitator design proved inadequate under the constraints of our mobile, self-powered platform; thus, novel electric space-charge driven approaches were developed for implementing on-the-go collection of charged dust onto grounded tree-leaf canopies. We report the theoretical basis for such a hybrid aerodynamic-electrostatic dust-abatement process as well as the engineering design and orchard evaluation of a full-scale harvester system having ~10 g/s PM_{2.5} dust emission at ~27 m/s in a ~7 m³/s exhaust plume. Figure 1 depicts this prototype operating in a California almond grove.

Index Terms - Electrostatic precipitation, Electrostatic deposition, Space-charge electric field, Ionized-field charging, Electrostatic-induction spray charging, Charged-droplet scrubbing, Bipolar charging, Respirable dust, Air quality, Cyclone separator, Nuts.

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Figure 1. Prototype of nut-harvester with aerodynamic-electrostatic abatement of respirable dust.