Drug Loading on Mineral Carriers: Close the Mass Balance

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Abstract. A loading percentage is useful only when its denominator and analytical recovery are defined. This guide separates feed depletion from drug measured on the recovered carrier and sets out the controls needed for an interpretable development comparison.

Keywords: HA; TCP; bioactive glass; drug loading; assay recovery

1. Define the analyte and product

State whether results refer to the parent drug, salt or active-moiety equivalent. Use that same basis in the feed, wash liquids and recovered product. Record carrier identity, lot, physical form and dry-mass basis.

Define whether the evaluated product is washed or unwashed. Record solvent, pH, contact conditions, separation, drying and all sampled fractions. A literature loading procedure is not automatically transferable between HA, TCP and bioactive glass.

2. Keep denominators visible

Loading efficiency (%) = retained drug / introduced drug × 100.

Carrier-normalized loading (mg/g) = retained drug / recovered dry carrier mass.

Composite drug content (%) = retained drug / total dry loaded-composite mass × 100.

The original glass study [1] distinguishes loading content and efficiency. Neither quantity alone proves how much active drug will be released.

3. Account for every fraction

Use a common analyte basis for the balance:
Feed = **mother liquor** + **washes** + **apparatus recovery** + **recovered-solid drug** + **unaccounted amount.**

Solution depletion estimates apparent association. Drug lost to tubes, filters, degradation or a separate precipitate must not silently become “loaded drug.” Include aliquots removed during loading and dilution factors.

Compare depletion with a recovery-qualified extraction of the recovered solid. Extraction must be challenged for incomplete recovery and drug alteration; performing an extraction does not establish that it is quantitative.

4. Qualify the analytical finish

Use unloaded-carrier matrix, drug-only process and spiked-matrix controls. Assess selectivity, working range, accuracy and precision under the actual preparation conditions [2].

In one glass study, the attempted UV–Vis measurement was not reproducible and HPLC was used for selected depletion measurements [1]. This is a method-specific observation, not a universal ranking of analytical methods.

5. Worked balance and development checklist

Hypothetical example, not product data: introduce 20.0 mg drug; recover 8.0 mg in mother liquor, 2.0 mg in washes and 0.5 mg in apparatus rinses. Depletion suggests 9.5 mg associated with the product. Direct solid extraction measures 9.0 mg.

Record / control	Minimum evidence to retain	Interpretation
Mass recovery	(8.0 + 2.0 + 0.5 + 9.0) / 20.0 × 100 = 97.5%	Keep the missing 0.5 mg unresolved.
Loading efficiency	9.0 / 20.0 × 100 = 45.0%	Use directly measured retained drug.
Carrier-normalized loading	9.0 mg / 0.200 g = 45.0 mg/g	Recovered dry carrier basis.
Composite content	9.0 / 209.0 × 100 = 4.31%	Assumes only carrier plus drug in dry product.
Matrix / process controls	Blank, drug-only recovery, matrix spike and extraction recovery	Separate assay bias from real association.
Replicate structure	Independent preparations and repeat injections identified separately	Instrument repeats are not independent loading runs.

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6. Decision and reporting limit

Compare candidates only after aligning the analyte, denominator, wash state and assay. Report the directly measured amount, depletion estimate, balance closure and variability separately. Define acceptable recovery and investigation criteria before comparing candidates; this guide sets no universal percentage threshold.

Scope

These calculations describe measured analyte, not biological activity. Neither high loading efficiency nor total organic mass establishes drug identity, availability, sterility, safety or therapeutic efficacy. Thermal or elemental data require an appropriate blank and a justified conversion to drug amount.

References and evidence boundaries

[1] Ce-MBGs Loaded with Gentamicin: Characterization and In Vitro Evaluation. J Funct Biomater. 2023;14:129. Published 26 February 2023. doi:10.3390/jfb14030129. Original glass-specific experimental evidence.

[2] FDA / ICH. Q2(R2), Validation of Analytical Procedures. March 2024. Official guidance PDF. Analytical principles applied here; no claim of a validated or compliant Kannrybio procedure.

Sources checked 30 October 2026. Research planning guidance only; no Kannrybio lot-performance, clinical or regulatory-approval claim.

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