A COMPARATIVE STUDY OF PRODUCT RECOVERY IN LABORATORY-SCALE SPRAY DRYERS: STANDARD CYCLONE VS. THE DISCOVERY MODULE

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PURPOSE

This study compares the product recovery performance of the Discovery Module against a standard cyclone separator in bench top and laboratory-scale spray drying systems. Efficient particle collection and recovery are critical in pharmaceutical manufacturing, particularly during early-stage research and the development of complex formulations. Traditional cyclone-based spray drying systems often experience material loss, particularly when processing small quantities or fine particles. The Discovery Module was developed to address these limitations by enhancing filtration efficiency and minimizing particle loss at the collection point. The evaluation includes both aqueous and solvent-based formulations processed using FREUND's GENESIS™ GSD-LAB Micro and GENESIS™ GSD-200.

OBJECTIVE

This work aims to evaluate the influence of the collection mechanism on yield across formulation types and equipment scales to quantify the Discovery Module's effectiveness in improving material recovery efficiency under varying process conditions.

METHODS

Formulations & Equipment

Solvent-based:
- HPMC-AS in acetone
- IND:EPO (1:4) in acetone
- Ketoconazole:HPMC-AS (1:4) in acetone and ethanol (1:1)

Aqueous:
- Maltodextrin in DI water

Spray Dryers:
- GSD-LAB Micro (10PSI, 10CFM)
- GSD-200 (15PSI, 17CFM)

Collectors:
- Discovery Module
- Standard cyclone separator

Analyzers
- Differential Scanning Calorimetry (DSC)
- QICPIC Helos Laser Diffraction
- Loss on Drying (LOD)

Trial Conditions and Measurements

1. Product & inlet temperatures matched across collectors for each formulation
2. Materials collected from Discovery Module or recovery chamber – Materials outside these parts (drying chamber, ducts, etc.) not collected
3. LOD, Particle Size, and DSC performed on samples to ensure continuity
4. Analytical scales used for all recoveries

Image 1. Discovery Module Inline

Table 1. Trial Formulations and Conditions

Formulation	Spray Dryer	Solvent/Base	Inlet Temp (°C)	Product Temp (°C)
HPMC-AS	GSD-LAB Micro	Acetone	80	44
Maltodextrin	GSD-LAB Micro	Water	190	101
IND:EPO (1:4)	GSD-LAB Micro	Acetone	110	55
Ketoconazole	GSD-LAB Micro	Acetone & Ethanol	160	87
Maltodextrin	GSD-200	Water	180	75
IND:EPO (1:4)	GSD-200	Acetone	60	44

RESULTS

Solvent-based formulations processed on the GSD-LAB Micro achieved up to a sixfold increase in yield (Table 2), while the GSD-200 exhibited more than a twofold improvement (Table 3). Even for aqueous formulations such as maltodextrin, yield improvements ranged from 2% to 23%, demonstrating the module's effectiveness across formulation types (Figure 3).

Three analytical methods were used to compare starting material to the spray dried product. A DSC which was used to verify the melting point of ketoconazole (~152 °C) in its crystalline state when compared to the glass transition temperature of the spray dried material (Figures 1 & 2). The DSC thermogram confirmed the formation of an amorphous solid dispersion (ASD), as evidenced by the absence of a melting endotherm associated with crystalline ketoconazole. A particle size distribution (PSD) graph showed that the collection vessel did not affect the particle size of the spray dried material (Figure 4). LOD testing proved that the final moisture of the spray dried material was consistent (± 0.05%) independent of collection vessel.

Table 2. Product Yield and Recovery on the GSD-LAB Micro

Trial	Collection Vessel	Formulation	Solids in Solution	Feed Rate (g/min)	Theoretical Solids Sprayed (g)	Yield (g)	Yield (%)
1	Discovery Module	HPMC-AS in Acetone	1%	1.20	0.10	0.0746	74.60
2	Standard Configuration	HPMC-AS in Acetone	1%	1.20	0.10	0.0158	15.80
3	Discovery Module	Maltodextrin in DI Water	25%	1.71	5.00	2.3900	47.80
4	Standard Configuration	Maltodextrin in DI Water	25%	1.97	5.00	2.2200	44.40
5	Discovery Module	IND:EPO 1:4	10%	2.47	1.74	0.6200	35.60
6	Standard Configuration	IND:EPO 1:4	10%	2.47	1.74	0.0900	5.17
7	Discovery Module	Ketoconazole	15%	1.47	3.18	2.0136	77.15
8	Standard Configuration	Ketoconazole	15%	1.45	2.61	1.0131	38.82

Table 3. Product Yield and Recovery on the GSD-200

Trial	Collection Vessel	Formulation	Solids in Solution	Feed Rate (g/min)	Theoretical Solids Sprayed (g)	Yield (g)	Yield (%)
1	Discovery Module	Maltodextrin in DI Water	25%	8.9	7.75	4.15	53.6
2	Standard Configuration	Maltodextrin in DI Water	25%	7.9	8.50	2.57	30.2
3	Discovery Module	IND:EPO 1:4	10%	7.2	7.60	2.91	38.3
4	Standard Configuration	IND:EPO 1:4	10%	7.3	7.50	1.42	18.9

Figure 3. Comparison of Product Yields: Discovery Module vs. Standard Configuration

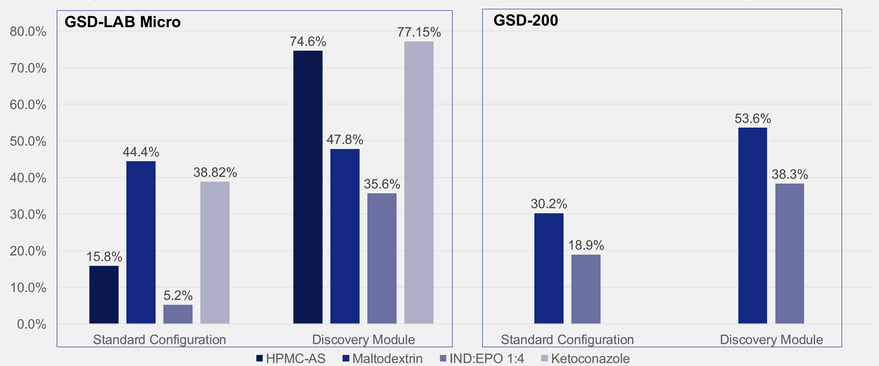

Figure 1. Pure Ketoconazole (KTZ)

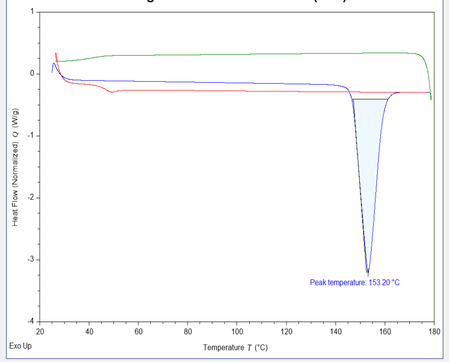

Figure 2. Ketoconazole:HMPC-AS Discovery Module Recovery

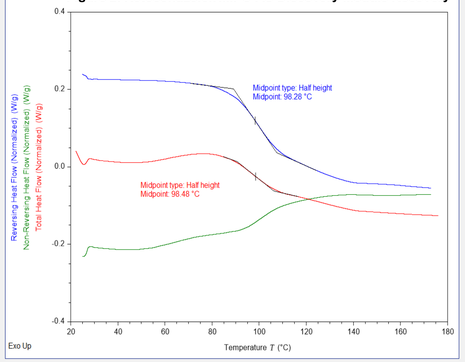

Figure 4. Particle Size Distribution of Ketoconazole

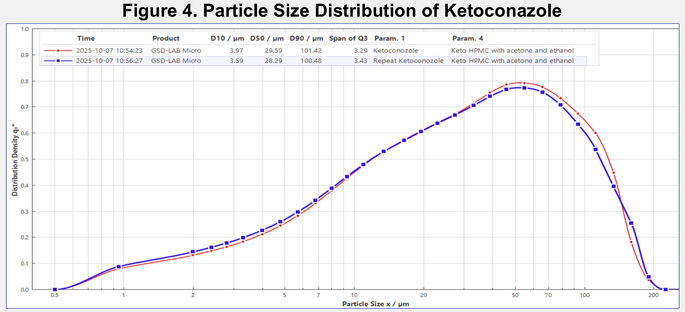

Image 2. Discovery Module Removed from System with IND:EPO

CONCLUSIONS

The integration of the Discovery Module into both benchtop GSD-LAB Micro and pilot-scale GSD-200 spray drying systems resulted in a substantial enhancement in product recovery across a range of formulation types. Yield improvements of up to sixfold were observed in solvent-based formulations on the GSD-LAB Micro, while the GSD-200 demonstrated more than a twofold increase. Even aqueous systems such as maltodextrin showed yield gains ranging from 2% to 23%, highlighting the module's broad applicability.
Collectively, these results validate the Discovery Module as an effective process enhancement tool that improves product recovery without compromising material quality. The module supports the reliable manufacture of molecular dispersions and reinforces the suitability of spray drying for ASD development, while also enabling scalability and process efficiency in pharmaceutical formulation workflows.

Image 2. GSD-LAB Micro

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