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A Taguchi-Simplex Algorithm for the Optimization of Tapped Density for Particulate Orange Peels

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A B S T R A C T

In the composite industry, green fillers transported between locations face undesirable impacts of road surface on powder loads but few methods accurately account for this challenge in tapped density measurements. The purpose of this paper is to introduce a methodology to help composite development engineers manage the transportation of orange particles in transit, on vehicles as they move from the particle production locations to the production process locations. In this paper, the Taguchi method-simplex algorithm (TM-SA) method is proposed for the tapped density optimization of orange peel particulates (OPPs). OPPs of 0.425 and 0.600mm for automobile applications are optimized using experimental data. Managing the transportation process of orange peel particulates and their outcomes needs managing substantial tapped density information. Taguchi method was integrated into the objective function of a simplex algorithm. The tapped density parameters were optimized at the lowest parametric values and the constraints were formulated. It was revealed that for the 0.425mm orange peel particulates, the optimal values and volumetric values were lower by 0.09% and lower by 4.06%, respectively. For the 0.600mm, the optimal values and volumetric values were higher by 0.005% and 6.91%, respectively, when the current method was compared with the literature values from the grey relational analysis. The results at optimality support the effectiveness of the method and were validated by the grey relational analysis results from the literature. The utility of our research is to help green filler powder manufacturers assure cost-effective decisions and logistics delivery optimization.

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1. INTRODUCTION

In the composite industry, a principal interesting development during the past few years is the advent of green fillers (Sarde et al., 2021; Saravanan et al., 2022; Ganguly et al., 2022; Sun et al., 2022; Sharif and Taykoli et al., 2023, Kim et al., 2023). Sharif and Tayakoli (2023) studied the combined chitosan and graphene oxide as green fillers. Its influence in enhancing the properties of epoxy composite such as impact, tensile and bending analysis was confirmed as positive. In addition, Kim et al. (2023) analysed the physiochemical features of *Chlorella sp*. HS2 is a particle derivation of CO_2-based biomass particles. They varied temperature and dispersion while the influence of its mechanical reinforcing in polymer composites was examined. Moreover, Sun et al. (2022) developed a thermally conductive green filter for composites based on polydopamine-adjusted graphene with cellulose nanofibers. Furthermore, Ganguly et al. (2022) produced hybrid composites to capture important thermal, electrical and mechanical properties of the composite as an outstanding green filler. Next, Saravanan et al. (2022) discussed the tribological features of green fillers with emphasis on their wear mechanism. Moreover, Sarde et al. (2021) assessed how effective palm oil fuel ash could serve as green filler when combined with methyl metacrylate.

Furthermore, Nagaprasad et al. (2022) employed integrated Date seed and Tamarind seed fillers as composite fillers. They reported success in improving the mechanical properties of composites with the mentioned fillers. Kumar et al. (2023) analyzed the mechanical performance of composites reinforced by the following green fillers: palm (Asian palmya), banana, jute and sisal fibres. They found these green fillers as excellent support in achieving enhanced tensile, impact and flexural strengths as well as hardness. Roy et al. (2021) presented a review of agricultural wastes and the extraction of cellulose from them to reinforce rubber composites. In sum, apart from these examples, elsewhere in the literature, the following green fillers have been used: coconut shells, orange peels, bamboo, cassava peels, maize cobs and palm kernels. Unlike synthetic fibres and metals, green fillers are usually environmentally friendly, low-cost costs and abundant at sources. Interestingly, of the green fillers mentioned, the specific focus of the current study is on orange peel particles (OPPs), which are emerging as substantially important fillers for agricultural structures such as silos.

In the composite industry, OPPs need to be transported from the base, usually from the powder-making industry, to a destination, which is the composite manufacturing industry. The practical situation is that the locations of these two industries may be several kilometres away, and these powders must be transported for commercial production of the composites. However, during the transportation of the orange peel powders, there are bound to be density changes as a result of the impacts of the roughness of the road surface on the powder loads. Consequently, at the delivery points where quantitative density measures are taken, the readings obtained may not agree with what it was at the on-loading point of the powder industry. This situation gives rise to confusion, conflicts, arguments, and loss of goodwill in the powder-making industry. Customer brand switching may occur and this leaves us with serious implications for decision making. As a result, a new approach is needed, which is scientific-based, easy to understand and of practical significance. With this in view, tapped density then becomes the most critical and much-needed tool in this situation (Xiao et al., 2006; Wei et al., 2012; Yang et al., 2012; Ajibade et al., 2016a,b).

Of late, the sparingly documented reports on the tapped density of OPPs have addressed the measurement aspect and very few attempts have been made concerning the optimization of OPPs. However, no single paper could be traced to the application of the Taguchi-simplex method to the tapped densification process of OPPs. Yet, the Taguchi-simplex method is a newly introduced optimization algorithm with growing applications in processes. Ajibade et al. (2015) first presented the idea of the Taguchi-simplex method but in the metal removal process optimization perspective. However, the utility of the method has not been tested beyond the machining domain. In recent times, the concern of optimization of the tapped density of orange peel particles has necessitated the use of the Taguchi method and grey relational analysis, among others (Ajibade et al., 2016c). In the paper by Ajibade et al. (2015), the authors conducted an optimization study of orange peel particles using grey relational analysis and the Taguchi method. They compared the results with two variants of the Taguchi method. While the results appear useful, there is ample opportunity for the improvement of the work. First, it is known that the part 80-20 rule has succeeded as a tool in manufacturing and its transferability to the case of tapped density optimization may be invested in. Thus, this rule could be applied to the S/N ratios of responses while Taguchi-simplex measures of the Pareto rule could be compared with the normal output of Taguchi-simplex. These two variants of the Taguchi simplex could be compared with those of the Taguchi method proposed by Ajibade et al. (2015).

This article aims to develop an approach to the optimization of tapped density through Taguchi-simplex evaluations and then evolve a variant of the Taguchi-simplex method. Using tapped density, without proper compatibility and compressibility characteristics among the particles of the orange peel particles (OPPs), the composite made of OPPs tends to delaminate as a result of the weak interrelationship between the particles (filler) and the matrix (epoxy, vinyl ester or polyester). Therefore the load transfer to the matrix will be significantly higher than what is expected and delamination may result. Thus, improving and optimizing the tapped density, which indirectly improves the compressibility and compatibility factors is necessary. This is a principal consideration in the development of OPPs as substitute filler material for composite manufacture.

Tapped density is a physical property evaluation process whereby particles of the filler are shaken in successive taps of the containing body against a rigid surface as to reduce the spacing among the particles of the specimens being considered. A limitation of the process is the uneven distribution of particles in taps during the manual tapping process. However, the optimization of the tapping process parameters is a promising tool which overcomes this limitation to a large extent. It provides optimal values of parameters and improves the compressibility and compatibility capabilities of the OPPs in their interactions with the matrix for their dispersion behavior.

The addition of optimally tapped densified OPPs to a matrix subsequently helps in the proper transfer of load from the filler to the matrix. Hence, the adequate understanding and treatment of the optimization of the tapped density of OPPs are fundamental for progress in the aspect of composite fabrication using OPPs as the filler. Tapped density is a crucial function of powdered products, especially for those in transportation to destinations where these powders are to be used for composite manufacture. The optimization of tapped density is currently widely encouraged by authors as a means of obtaining improved measuring parameters of the tapped density process. The accuracy of the method used for the optimization process dictates the choice of the optimization technique for the process of interest.

Having conducted a literature review on the current investigation, it became obvious to the current author that optimization of process parameters in tapped density experimentations could potentially enhance the performance of the system for possible applications in areas as diverse as sporting, household facility manufacture, agricultural storage facilities such as silos and more. Consequently, the research on tapped density using the Taguchi-simplex algorithm was chosen as the pursued title for the current investigation.

2. THE PROPOSED METHODOLOGY FOR THE TM-SA METHOD

Over the years, the contributions of researchers in the use of two distinct methods of Taguchi method and the simplex algorithm have been impressive. Taguchi in 1990 introduced an optimization revolution in engineering which encourages researchers and practitioners to reduce experimental costs through the design of experiments. This provides fewer experimental counts to achieve optimization goals. Previously in 1939, George Dantzig had laid a foundation of a simplex algorithm that had served researchers for decades in the drive for optimization. Its merits include no requirements for derivation functions, easy to use and provisions for multiple variable usage in the model (Ajibade et al., 2015). Interestingly, while the TM and SA methods had been used independently for decades in the engineering field, only in

2015 was the first attempt made to integrate the TM and SA methods to the best knowledge of the authors. The application was made by Ajibade et al. (2015) for the metal removal process. Also, this is the first application of the integrated TM-SA method to the green filler domain in composite development research. The following are the important steps of the approach:

1. Obtain the optimal parametric setting from the Taguchi method
2. Extract information on the lowest and highest levels of each parameter and set them as the lower and upper boundaries for the problem.
3. Obtain the signal-to-noise information from the response table
4. Decide on the type of optimization problem which may be either minimization or maximization.
5. Develop the objective function and the constraints of the linear programming formulated
6. Solve the formulated Program: A linear Program solver may be used for this purpose.
7. Interpret the results for decision-making.

3. RESULTS AND DISCUSSION

To implement the TM-SA method in the current work, experimental data from a preliminary experiment was used. The TM-SA method was declared to have a cost advantage and guarantees an event where an array of variables that provides ease of computation is made (Ajibade et al., 2015). The case study was examined and optimal data was extracted for use in the present work. Furthermore, an automobile product is targeted to be produced from the tapped-density orange peels. In the automobile, several possible products could be created from the orange peel particulate composites, including the following: rearview mirror, vehicle audio system, cup holder and floor carpet. However, among these alternative products, the use of tapped particulate orange peels as reinforcements for composites may be a good fit for the floor carpet of a car. Beyond the conventional production approach, which involves weaving, a new direction for production is proposed. The final output of this process may compacted and the extrusion and compaction principles used in the creation of the new product.

Now, the issue is to show how the floor carpet is processed. By using the process of extrusion, the orange particulates are passed through a nozzle that shapes in length and breadth in a viscous state of the particulate orange peels. However, this is implemented under high pressure as well as intense temperatures. Consequently, extrudes are produced, which vary both in length and breadth, according to the configuration of the floor carpet desired. Notice that the cross-sectional area of the extrudates mimics that of the nozzle design, allowing simplified and even complicated shapes of the floor carpet to be produced. However, despite this interesting process, achieving the quality objective regarding uniformity of extrusion is a challenge.

The problem is that as particles are moved from the preparatory stage in one location to the production stage in another, undesired compaction of the orange particles takes place on the road as the vehicle passes through vehicles of different topographies. The issue is that as vehicles carrying orange peel particulates pass through pot holes on the roads, there is an unintended tapping of the particles that is desired. Notwithstanding, by understanding existing research discussions and theories, it is known that tapping could be done on these particles in the laboratory to understand the maximum threshold permitted. The phenomenon of optimizing the tapping of these orange peel particles is not fully studied in the literature and it is a research gap to be addressed in the present study. The idea is that once optimal thresholds are computed, such information could be used for planning to decide how the packing of the particulate boxes will be done before transporting them to production locations.

Taguchi method (TM) has been used to optimize the tapped density parameters of 0.425 and 0.600 mm OPPs, which produced an optimal parametric setting of $G_2H_2I_1J_1$ (Ajibade et al., 2016a,b). The optimal parametric setting can be read as 257.723 g and 75.031 cm^3 for the 0.425 mm as well as 254.952 g and 77.982 cm^3 for the 0.600 mm particles, respectively. To enhance the optimal results obtained by the TM for improved composite demands, the TM optimal results were integrated into the objective function of a simplex algorithm. Thus, the tapped density parameters will be optimized using the lowest level of the parameters as the initial constraint while the optimal values from the Taguchi method become the higher constraint. The optimal parametric setting of $G_2H_2I_1J_1$ from the S/N response table is translated to S/N ratios as follows.

$[G_2H_2I_1J_1]$ = [-6.8494, -6.84728, -6.84956, -6.84954]

Since we want to improve the optimal results from the Taguchi LB quality characteristics, the Taguchi-simplex optimization is a minimization problem. Thus, we have:

$$\text{Minimize } D_t = \sum_{p=1}^{q} \phi_p k_p \quad (1)$$

Subject to

$257.715 \leq M_{0.425} \geq 257.723$ (2)

$72.736 \leq V_{0.425} \geq 75.031$ (3)

$254.91 \leq M_{0.600} \geq 254.952$ (4)

$71.958 \leq V_{0.600} \geq 77.982$ (5)

Using the above-given constraints, where $\phi_1 = \phi_2 = \phi_3 = \phi_4$ and $k_1 = M_{0.425}$, $k_2 = V_{0.425}$, $k_3 = M_{0.600}$, $k_4 = V_{0.600}$. Integrating the S/N ratios into the objective function, equation (1) could be treated as

$$\text{Minimize } D_t = -6.8494M_{0.425} - 6.84728V_{0.425} - 6.84956M_{0.600} - 6.84954V_{0.600} \quad (5a)$$

Subject to

0.425 mm mass, $M_{0.425}$ (g)

$M_{0.425} \geq 257.715$ (6a)

$M_{0.425} \leq 257.723$ (6b)

0.425 mm volume, $V_{0.425}$ (cm^3)

$V_{0.425} \geq 72.736$ (7a)

$V_{0.425} \leq 75.031$ (7b)

0.600 mm mass, $M_{0.600}$ (g)

$M_{0.600} \geq 254.91$ (8a)

$M_{0.600} \leq 254.952$ (8b)

0.600 mm volume, $V_{0.600}$ (cm^3)

$V_{0.600} \geq 71.958$ (9a)

$V_{0.600} \leq 77.982$ (9b)

Equations (6a) to (9b) can be further broken down since they both have "$\leq$ and $\geq$" attached to them. Thus, we have

Minimize $D_t = -6.8494M_{0.425} - 6.84728V_{0.425} - 6.84956M_{0.600} - 6.84954V_{0.600}$

Expressing the tapped density optimization problem in standard form, where slack and surplus variables are applied. Then, J_1, J_2, J_3, and J_4 are adapted to this present problem by adding them to equations (6a) to (9b).

Thus, the following equations are valid

Minimize $D_t = -6.8494M_{0.425} - 6.84728V_{0.425} - 6.84956M_{0.600} - 6.84954V_{0.600}$

$M_{0.425} - J_1 = 257.715$ (10a)

$M_{0.425} + J_1 = 257.723$ (10b)

$V_{0.425} - J_2 = 72.736$ (11a)

$V_{0.425} + J_2 = 75.031$ (11b)

$M_{0.600} - J_3 = 254.91$ (12a)

$M_{0.600} + J_3 = 254.952$ (12b)

$V_{0.600} - J_4 = 71.958$ (13a)

$V_{0.600} + J_4 = 77.982$ (13b)

The non-negativity constraint is given as $M_{0.425}$, $V_{0.425}$, $M_{0.600}$, $V_{0.600} \geq 0$. Assume that J_1=257.715 or 257.723, J_2= 72.736 or 75.031, J_3= 254.91 or 254.952, J_4=71.958 or 77.982, where the variables J_1, J_2, J_3 *and* J_4 are the slacks associated with the respective constraints. This is followed by rewriting the objective equation as

Minimize $D_t + 6.8494M_{0.425} + 6.84728V_{0.425} + 6.84956M_{0.600} + 6.84954V_{0.600} = 0$

The starting Taguchi-simplex tableau is given in Table 1.

Table 1. Starting Taguchi-simplex tableau

Basic	D_t	$M_{0.425}$	$V_{0.425}$	$M_{0.600}$	$V_{0.600}$	J_1	J_2	J_3	J_4	*Soltn*
D_t	1	6.8494	6.84728	6.84956	6.84954	0	0	0	0	0
J_1	0	1	0	0	0	1	0	0	0	257.723
J_2	0	0	1	0	0	0	1	0	0	75.031
J_3	0	0	0	1	0	0	0	1	0	254.952
J_4	0	0	0	0	1	0	0	0	1	77.982

Using the optimality and feasibility conditions, $M_{0.600}$ and J_3 become the entering and leaving variables respectively. J_3 is replaced by $M_{0.600}$ in the basic column and the rest of the swapping process is completed using the Gauss-Jordan row operations. The iterations of the tableau continue to produce a new Taguchi-simplex tableau. A total of 4 iterations are carried out till the optimal tableau is reached in Table 2. The intermediate results obtained are discussed in the relevant section. From Table 2, none of the D_t row coefficients associated with the non-basic variables J_1, J_2, J_3 *and* J_4 is positive, the last tableau is considered optimal. The optimal values of the variables in the basic column are given in the right-hand side "solution" column and are interpreted in Table 3.

i) New $M_{0.600}$ row = $\begin{pmatrix}0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 254.952\end{pmatrix}$

ii) New D_t row = $\begin{pmatrix}1 & 6.8494 & 6.84728 & 0 & 6.84954 & 0 & 0 & 6.84956 & 0 & 1746.3\end{pmatrix}$

iii) New J_1 row = $\begin{pmatrix}0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 257.723\end{pmatrix}$

iv) New J_2 row = $\begin{pmatrix}0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 75.031\end{pmatrix}$

v) New J_4 row = $\begin{pmatrix}0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 77.982\end{pmatrix}$

Table 2. Optimal Taguchi-simplex tableau

Basic	D_t	$M_{0.425}$	$V_{0.425}$	$M_{0.600}$	$V_{0.600}$	J_1	J_2	J_3	J_4	*Soltn*
D_t	1	0	0	0	0	6.8494	6.84728	6.84956	6.84954	4556.45
$M_{0.425}$	0	1	0	0	0	1	0	0	0	257.723
$V_{0.425}$	0	0	1	0	0	0	1	0	0	75.031
$M_{0.600}$	0	0	0	1	0	0	0	1	0	254.952
$V_{0.600}$	0	0	0	0	1	0	0	0	1	77.982

Table 3. Interpretation table

Decision variable	Optimum value	Recommendation
$M_{0.425}$	257.723 g	257.723 g of 0.425 mm is required for optimal tapped density
$V_{0.425}$	75.031 cm^3	75.031 cm^3 volume of 0.425 mm is adequate for optimal tapped density
$M_{0.600}$	254.952 g	254.952 g of 0.600 mm is required for optimal tapped density
$V_{0.600}$	77.982 cm^3	77.982 cm^3 volume of 0.600 mm is adequate for optimal tapped density

4. CONCLUSIONS

This article approaches the optimization of green fillers under the tapped density process through a novel approach named TM-SA. This approach determines the optimal parametric setting for two grades of sieved orange peels, notably the 0.425 and 0.600mm orange peels. A case study, which extracts data from a previously implemented project is considered. The combination of the Taguchi method and simplex algorithm was made in anticipation of reducing experimental costs and concurrently permitting several variables for testing (Ajibade et al., 2015). The application of the TM-SA method was found to be feasible in the case of tapped density optimization of 0.425 and 0.600mm. For the 0.425mm orange peel particulate, the optimal value obtained is 257.723g and the volumetric measurement is 75.031cm^3.

Since minimization is desired, this result is slightly lower than 257.956g by 0.09% and also slightly lower than 78.076cm by 4.06% compared with the 0.425mm orange particulate tapped process obtained by the grey relational analysis. Furthermore, for the 0.600mm orange peel particulate, the optimization value obtained is 254.952g and the volumetric measurement is 77.982cm^3. The obtained result is slightly higher than 254.939g by 0.005% and also slightly higher than 72.94cm^3 by 6.91% compared with the 0.600mm orange peel particulate tapped scheme that the grey relational analysis yielded. From these results, the TM-SA method is slightly better than the grey relational analysis results of 0.425mm and slightly worse than the results of 0.600mm. therefore the proposed TM-SA method exhibited competitive optimization outcomes with the grey relational analysis with a better result in one case and a worse outcome in the other result.

The results at optimality reveal that the grey relational optimization result validates the effectiveness of the present proposed method of TM- SA. For future endeavors, it is suggested that researchers may experiment with other grades of orange peels in the micro group. Nanoparticles could also be experimented upon. Besides, a useful avenue for further research is to attempt non-conventional methods of optimization such as the Harris hawk algorithm. A limitation of the study is the possibility of having limited information (data) for processing, which can be overcome by deploying fuzzy sets or rough sets in future studies.

REFERENCES

Ajibade O.A., Agunsoye J.O., Oke S.A., 2015, Metal removal process optimisation using Taguchi-simplex method with case study applications, Cankaya University Journal of Science and Engineering, Vol. 12, No. 2, pp. 033-058. https://dergipark.org.tr/en/pub/cankujse/issue/33129/368638

Ajibade O.A., Agunsoye J.O., Oke S.A., 2016a, Tapped density optimisation for four agricultural wastes: Part I – Taguchi technique and mean response determination, Acta Periodica Technologica, Vol. 47, pp. 109-127. https://doi.org/10.2298/APT1647109A

Ajibade O.A., Agunsoye J.O., Oke S.A., 2016b, Tapped density optimisation for four agricultural wastes: Part II - Performance analysis, main effects of process parameters and Taguchi-Pareto, Acta Periodica Technologica, Vol. 47, pp. 129-142. https://doi.org/10.2298/APT1647129A

Ajibade O.A., Agunsoye J.O., Oke S.A., 2016c, A grey relational analytical approach to orange peel filler particulates for tapped density experiments of green composite reinforcements, KKU Engineering Journal, Vol. 43, No. 3, pp. 108-119. https://doi.org/10.14456/kkuenj.2016.17

Ganguly D., Bera A., Hore R., Khanra S., Maji P.K., Kotnjess D.K., Chattopadhyan S., 2022, Coining the attributes of nano to micro dual hybrid silica-ceramic waste filler based green HNBR composites for triple percolation: Mechanical properties, thermal and electrical conductivity, Chemical Engineering Journal Advance, Vol. 11, Article 100338. https://doi.org/10.1016/j.ceja.2022.100338

Kim J.H., Yan J.H., Hong J.S., Lee J.S., Sun S. J. Ahn K.H., 2023, CO_2-derived microalgae as a biomass filler to fabricate green composite, Materials Today Sustainability, Article 100582. https://doi.org/10.1016/j.mtsust.2023.100582

Kumar S.S., Vignesh V., Prasad V.V.S.H., Sumil B.D.Y, Srinivas R., Sanjay M.R., Siengchin S., 2023, static and dynamic mechanical analysis of hybrid natural fibre composites for engineering applications, Biomass Conversion and Biorefinery. https://doi.org/10,1007/513399-022-03689-2

Nagaprasad N., Vignesh V., Karthi K-Babour N.B., Manimaran P., Stalin B., Ramaswamy K., 2022, Effect of green hybrid fillers loading on mechanical and thermal properties of vinyl ester composites, Polymer composites, Vol.43, No. 11, pp.7928-7939. https://doi.org/10.1002/pc.26925

Roy K., Pongwisnthiruchte A., Debinath S.C, Potivarj P., 2021, Application of cellulose as green filler for the development of sustainable rubber technology, Current Research in Green and Sustainable Chemistry, Vol.4, Article 100140. https:doi.org/10.1016/j.crgsc.2021.100140

Saravanan D., Sollapur S. B., Anjappa S. B., Mall C., Prasad M. S., Vignesh S., 2022, TRibological properties of filler and green filler reinforced polymer composite, Material Today: Proceedings, Vol. 50, No.5, pp. 2065-2072. https:doi.org/10.1016/j.matpr.2021.09.414

Sarde B., Patil Y.D., Dhalakiya B.Z., 2021, Evaluation of effectiveness of palm oil fuel as green filler and methyl metacrylate as additive in recycled PET resin polymer composite, Journal of Building Engineering, Vol. 43, Article 103107. https://doi.org/10.1016/j.jobe.2021.103107

Sharif M. and Tayakol S., 2023, Biodegradable chistosan-graphene oxide as an effective green filler for improving of properties in epoxy nanocomposites, International Journal of Biological Macromolecules, Vol. 233, Article 123550. https://doi.org/10.1016/ijbiomac.2023.123550

Sun Z., Liu, Y., Wong R., Yu, M., Li J., Moran M., Zhang M., Dahariya S., Wong C.-P, 2022, Polydopamine-modifiedgraphene with cellulose nanofibers to act as fillers in epoxy nanocomposites for application in the next generation of green electronic packaging materials, Chemical Engineering Journal, Vol. 450, No. 3, Article 138299. https://doi.org/10.1016/j.cej.2022.13829

Wei W., Dezhi C., Ruining W. and Lin G., 2012. Hierarchial LiFEPO4/C microspheres with high tap density assembled by nanosheets as cathode materials for high performance Li-ion batteries, Nanotechnology, Vol.23, No 47. https://doi.org/10.1088/0957-4484/23/47/475401

Xiao J., Wang J., Liu Y., Li J., Li Y., 2006. Preparation of spherical cobalt carbonate powder with high tap density, Journal of Central South University of technology, Vol. 13, No. 6, pp. 642-646. https://doi.org/10.1007/s11771-006-0008-6

Yang S., Wang X., Yang X., Liu Z., Wei Q., and Shu H., 2012. High tap density spherical $Li[Ni_{0.5}Mn_{0.3}Co_{0.2}]O_2$ cathode material synthesized via continuous hydroxide co precipitation method for advanced Lithium-ion batteries, International Journal of Electrochemistry, Article ID 323560. https://doi.org/10.1155/2012/323560