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Appropriate Technology for the Paper Recycling: A New Paradigm

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Abstract

Every day a huge amount of paper is being used, most of them are thrown after using. This directly impacts on the environment. Therefore, waste paper management is necessity to protect the environment from its annihilation and pollution. Paper recycling products consist of printing paper, newspaper, corrugated containers, magazine paper and so on. Reuse waste paper will reduce the consumption of wood and virgin pulp as recycling one ton of newsprint can save approximately 1 ton of wood, meanwhile recycling 1 ton of printing paper can save more than 2 tons of wood. With increasing recycling rates, lower quality paper fractions may be included. Thus the selection of a paper recycling technology is a crucial first design consideration. The paper recycling must be accompanied by appropriate technology to manage a huge volume of wastepaper. The specific objectives of this study were as follows: (1) comprehensive literature reviews of paper production and consumption, (2) figure out about paper recovery and utilization, (3) investigate the paper recycling in the sustainable times, (4) introduce eco-friendly recycling technology to paper industry.

Key words : paper recycling, in-situ precipitated calcium carbonate, waste paper

1.Introduction

The paper industry is playing a key role in the socio-economic growth, leading to a significant decline of poverty rates in many countries. According to the Institute of Pulp and Paper Industry, in 2017, the total amount of paper packaging used worldwide among industries is summarized as follows: Food packaging occupies more than 50%, electricity nearly 20% of pharmaceuticals, about 10% of pharmaceuticals and other industries of more than 20%. This shows that the paper packaging industry in the world plays a very important role in many industries, in particular the consumer goods industry [1]. The paper and paper board production is being increased in every year. In 2010, the annual global paper and paperboard production was approximately 402 million tons. It is expected to increase to 490 million tons by 2020 (Figure 1).

Despite great contribution to the economic profile in the world but since pulp and paper industry has a high carbon footprint, it is a major consumer of energy and a major cause of greenhouse gas emissions. To produce 1 ton of newspaper, it takes 24 trees. Recent studies show that 30 - 40% of municipal solid waste is paper and paper products, and 50% of office waste paper entering burial sites. Greenhouse gas-based paper waste is generated at different stages in the life-cycle of the paper. Waste paper

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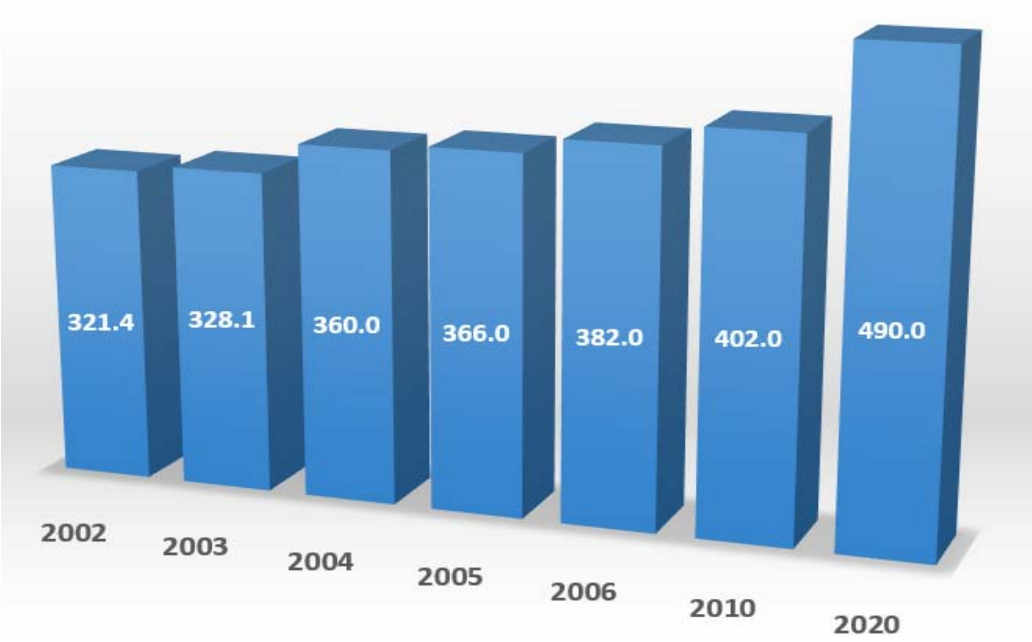

Figure 1. Paper and paperboard production- global market during, 2002-2020 (figures in million tons).

alone accounts for 48% of greenhouse gas emissions in the production process and also releases tons of "urban waste" to landfills.

Paper recycling is an important part of the solution to climate change because increasing the use of recycled pulp assists to decrease greenhouse gasses by less cutting down trees, offers energy savings via decrease amount of chemical pulping, and reduces the manufacture costs. Paper recycling can cut down supply chain below 80% and save compared with the paper made from wood pulp [2]. Recycling paper is a green and economical selection of paper mill compared to use the wood pulp as raw materials. According to the recycling guide website, recycled paper produces 73% less air pollution than if the paper was made from wood pulps [3]. For each ton of recycled paper to be recycled into cardboard for packaging and other uses, approximately 3.6 million tons of CO_2 emissions are eliminated. Moreover, recycling paper will save a lot more than the cost of buying pulp for making paper.

In this research, we study about the overview of the paper production and consumption, paper recovery and utilization and paper recycling in the sustainable times in the world and provide the appropriate technology for paper recycling named in-situ precipitated calcium carbonate.

2. Overview of existing situation

2.1 Paper production and consumption

Paper & board production within the European study region is forecast to grow from 101 million tons in 2005 to 122 million tons by 2015 based on a series of interviews during early 2008 (Figure 2). This equates to an average annual growth of 1.8% per annum for the ten-year period up to 2015 [4].

Paper and cardboard products from virgin pulp or waste paper pulp can be grouped into four large groups related to their utilization including for information, packaging, hygienic and others. The two largest utilization portions of paper are for information (graphic papers: 41.7 Mt) and packaging (36.0 Mt), accounting for 47% and 41% of the total share among Confederation of European Paper Industries (CEPI) countries in 2008 (CEPI, 2009c). The statistics of paper including production, consumption, collection, and recycling in 2008 in CEPI countries are given in table 1 below (adapted from CEPI, 2010) [5].

Table 1. Statistics for paper production, consumption, collection, and recycling in 2008 in CEPI countries (adapted from CEPI, 2010).

Indicator	Amounts/Percentages
Paper production (A)	99.002 Mt
Paper consumption (B)	87.444 Mt
Waste paper collection (C) herewith pre-consumer	58.995 Mt ca. 9 Mt
Waste paper utilization [recycling] (D)	48.616 Mt
Waste paper net trade (NT=C-D)	10.379 Mt
Utilization rate (D/A)	49.6%
Recovery rate ((C-landfilling-non-collectable)/B)	43.1%
Recycling rate (D/B) Recycling rate (incl. net trade): (C/B)	55.6% 67.5%

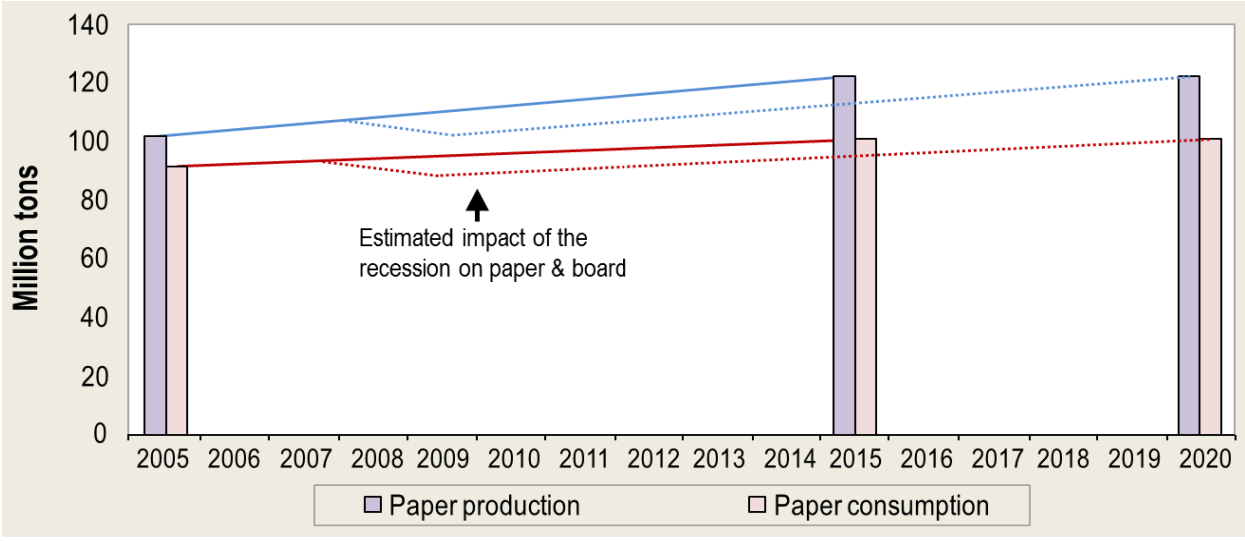

Figure 2. European paper & board production and consumption development during the period 2005 to 2015 (2019- 2021 projection).

2.2 Paper recovery and utilization

Waste paper is collected mainly from three sources: Industrial sources, commercial sources, and households and small businesses. Out of all waste paper, roughly 50% originates from industrial and large commercial sources, and the remaining 50% from households, offices and small businesses [5].

The paper industry expects that the overall world paper demand will increase by 25% by 2020 [5]. A decrease in the production of paper waste is not expected. And therefore, the importance of recovered paper as a raw material in the paper industry has increased substantially. Recovered paper is already the most important source of fiber in the industry worldwide, as recovered paper provided approximately 51% of all fiber used in the paper industry in 2006 [6]. There are clear signals this trend will continue with international forest and

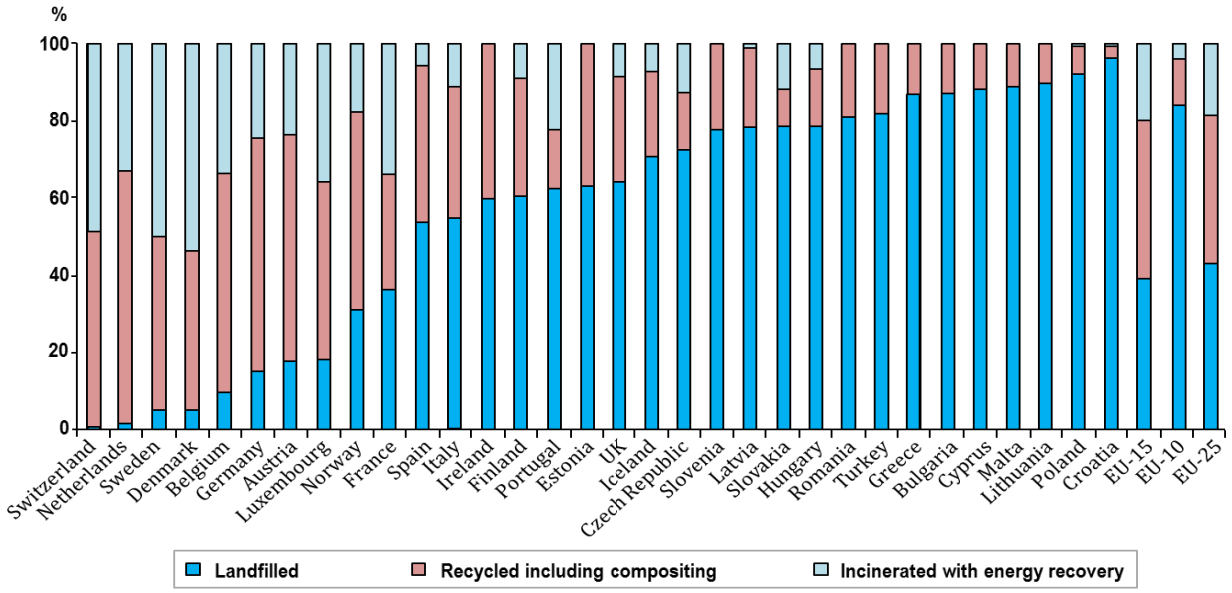

Figure 4. Differences among European countries in recycling (including composting), incineration and landfilling [6]. *(Source: EEA, 2007)*

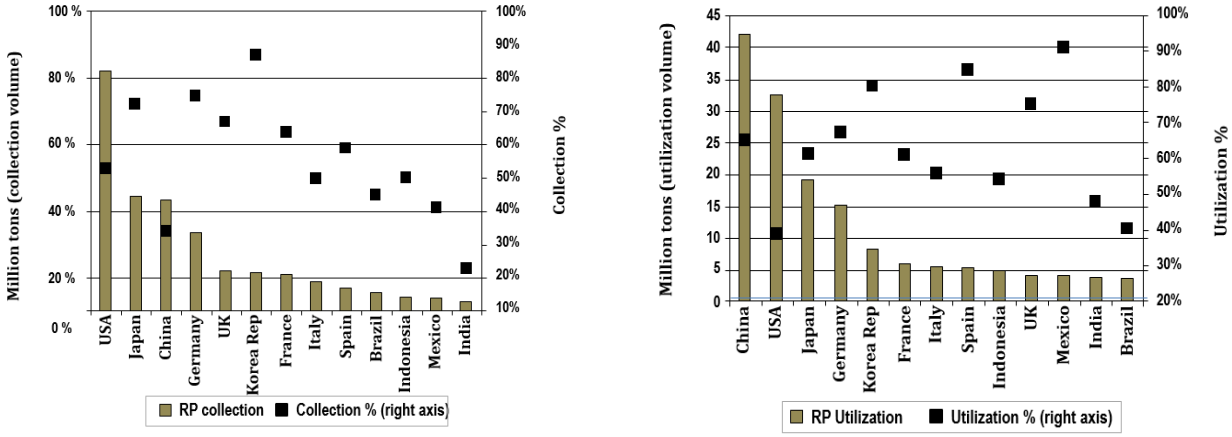

Figure 3. The volume and rate of recovered paper collection and utilization in selected countries in 2006 [4].

paper associations setting recovered fiber utilization rate targets as high as 70%: For example, the American Forest & Paper Association (70% by 2020); the Japan Paper Association (64% by 2015); and the European Recovered Paper Council (reached 71.7% in 2013) [6, 7].

Recovered paper utilization volumes and utilization rates vary greatly by country. In 2006, the thirteen most important countries (Figure 3) collected and utilized 153 and 155 million tons respectively or 78% and 79% of all recovered and utilized waste paper, globally. Already the most important four countries, namely China, the USA, Japan, and Germany utilized over 108 million tons or 55% of global recovered paper [4]. Not surprisingly, countries with vast forest resources and a strong wood pulp industry have based their raw material sourcing on virgin fibers, then the recovered paper utilization rate has been modest, and oppositely.

2.3 Paper recycling in the sustainable times

Many industries have undergone substantial changes towards renewable resources to replace non-renewable materials. Thus, the optimization of product

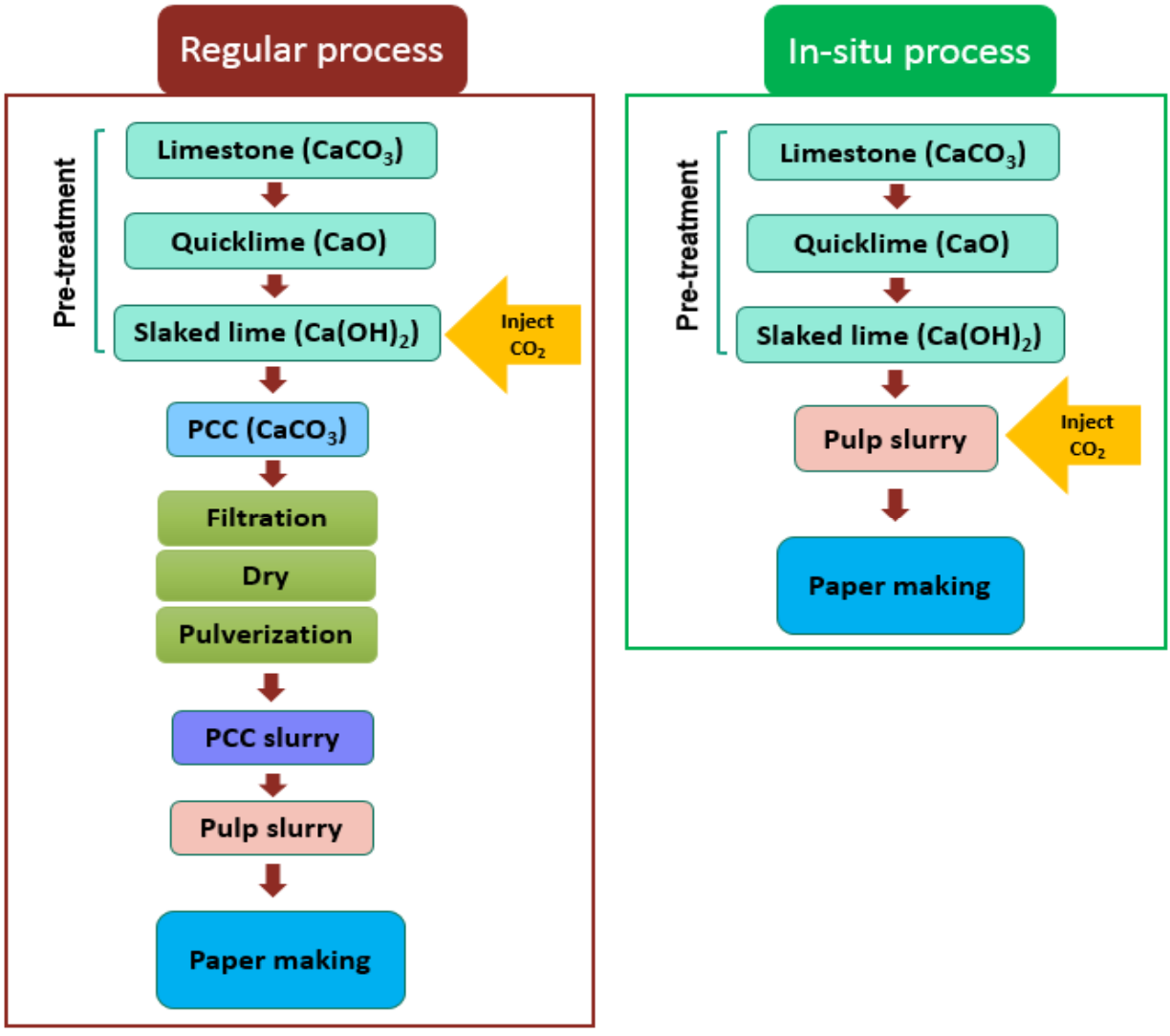

Figure 5. Compare between regular process and in-situ precipitation calcium carbonate (PCC) process on making paper.

life-cycles has become another core objective of the manufacturing industries. The life-cycle emission data

Table 2. The life-cycle emissions for the production of paper from virgin and recycled materials (kg CO_2/ton paper) [8, 9].

Paper type	From virgin materials	From recycled materials
Newsprint	1755	849
newsprint	2222	1535
Kraft paper unbleached	1080	633
Graphic paper	436 (uncoated)	586 (with deinking)
Graphic paper	730 (coated)	380 (without deinking)
Corrugated board	644 (25 % recycled)	522-536

from several studies regarding the recycling of paper products is summarized in table 2 (Smith et al, 2001) [8]. As can be seen, emissions over the life-cycle of a recycled paper product are substantially lower compared to the emissions from virgin materials. The motivation for recycling of paper is the notion that recovered paper is too valuable a resource to send to a landfill or to incinerate. Instead, the valuable raw material can be recycled to create new paper and cardboard.

Worldwide, paper-recycling rates have reached approximately 50%, which basically means that half of the waste paper products are sent to incineration plants or landfills. Although many countries are approaching or are at their practical limits, there is still much potential for the technology of paper recycling according to the IEA (2010). The high global recycling rate is achieved primarily due to high recycling rates in developed countries, and as such, recycling rates in developing countries can still be substantially improved. As an illustration, despite strong support for a variety of material recovery measures, including the inherent value of the waste products, landfilling is still the most common method of waste management (Figure 4) [9]. This illustrates that paper recovery management measures still have the potential for improvement.

3. cycling technology

In the paper recycling industry, in-situ precipitated calcium carbonate (PCC) is one of the best technologies for paper recycling. The technology enhances the brightness and durability of paper [10, 11]. In addition, the method can utilize CO_2 captured from many factories such as coal-fired power plants, cement manufactories. In-situ PCC also employs limestone which is abundant in nature. The technology has been patented and applied in the paper recycling industry as well as the lime-paper industry in Korea.

Basically, the in-situ PCC technology is the calcium carbonate forming process of on old newspapers (ONP), old corrugated cardboard (OCC) or kraft pulp (KP) by introducing carbon dioxide gas. Precipitated $CaCO_3$ particles will be in-situ formed on the surface of paper fibers through carbonate reactions. Because of enhancing the scattering coefficient higher than the conventional method of loading calcium carbonate precipitates on the paper fibers, the in-situ PCC improves the opacity of the paper. In general, the precipitated calcium carbonate can describe by two methods: regular PCC and in-situ PCC. In the regular PCC process, quicklime CaO converts to slaked lime $Ca(OH)_2$ through the hydraulic process. CO_2 gas is injected to turn $Ca(OH)_2$ to $CaCO_3$ (PCC). After filtration, drying and pulverization process, the PCC slurry is created. Finally, PCC and pulp slurry are mixed together to improve PCC attachment on the paper fiber surface (Figure 5 (left)). On the other hand, in the in-situ PCC process, CO_2 is directly introduced in the pulp slurry to form precipitated calcium carbonate (PCC) on the paper fiber surface via carbonation reaction [12-14] (Figure 5 (right) and Figure 6).

Compared to the regular process, in-situ PCC process can enhance paper opacity by increasing the scattering coefficient. In addition, the new technology also enhances the product quality in ash content increases the durability of paper. One more advantage of this technology is energy saving due to improved water separation and no drying required.

In fact, it is very difficult to increase the ash content by 1%, especially at the same time ensuring the properties of glass temperature and opacity. The in-situ PCC can both increase the ash content and utilize 8-10% CO_2 gas. This is the best way to capture and sequestration of CO_2 gas and utilization and more valuable to climate change by reducing the CO_2 emission.

Most for all, the in-situ PCC processes are environment-friendly because the technology can utilize CO_2 generated from the paper industry and reduce

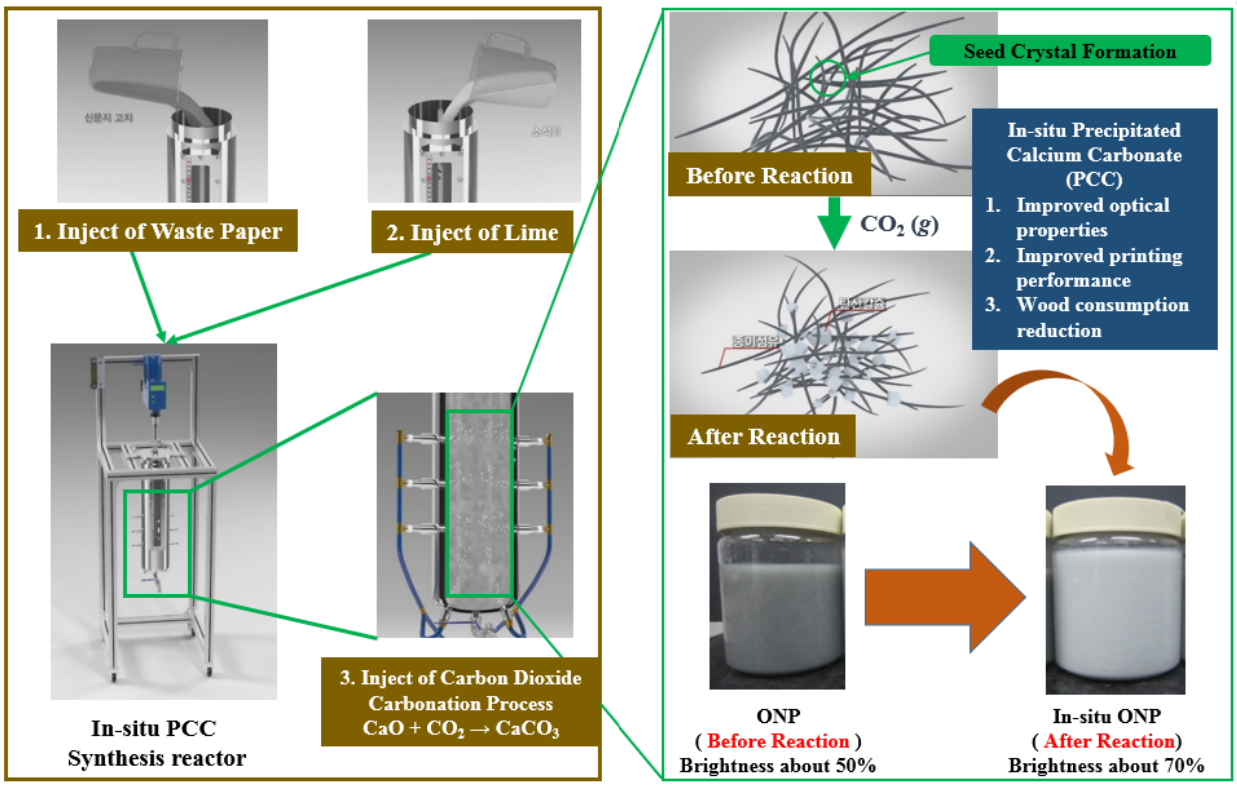

Figure 6. In-situ precipitation calcium carbonate (PCC) process.

the consumed wood pulp. Moreover, the method not only discharges less wastewater and by-products during the paper production process but also consume lower energy since shorter purification and drying times. Calculated results show that if 1 ton of waste paper recycles, it can reduce 937 kg CO_2 emissions, 3.22 KWh of electricity, 42,465 liters of water, and 340 kg of wastes.

4. Conclusion

Paper recycling is an integral part of paper and pulp industry and it offers significant environmental benefits. The most important goal is find out an appropriate technology for paper recycling which both high quality paper recover and environmental protection as well as cost-effective manufacture. While the optical property of paper from recycled wastepaper is very low, in-situ precipitated calcium carbonate technology can improve paper brightness. In addition, the method determines not only environmentally friendly, such as the easy recycling of CO_2 generated from the paper industry; reduce the consumption of wood materials; discharge less wastewater and by-products during paper production process; and lower energy consumption due to shorter purification and drying times, but also reduce significant cost of paper manufacture. Thus, in-situ PCC technology is a promising prospect of paper recycling industry.

Acknowledgments

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